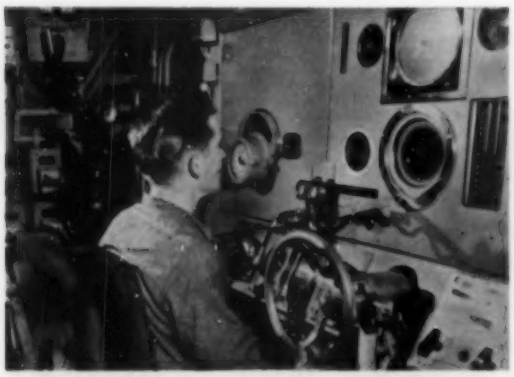
$3 A YEAR

PRODUCT ENGINEERING

cGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · MAY 2, 1960



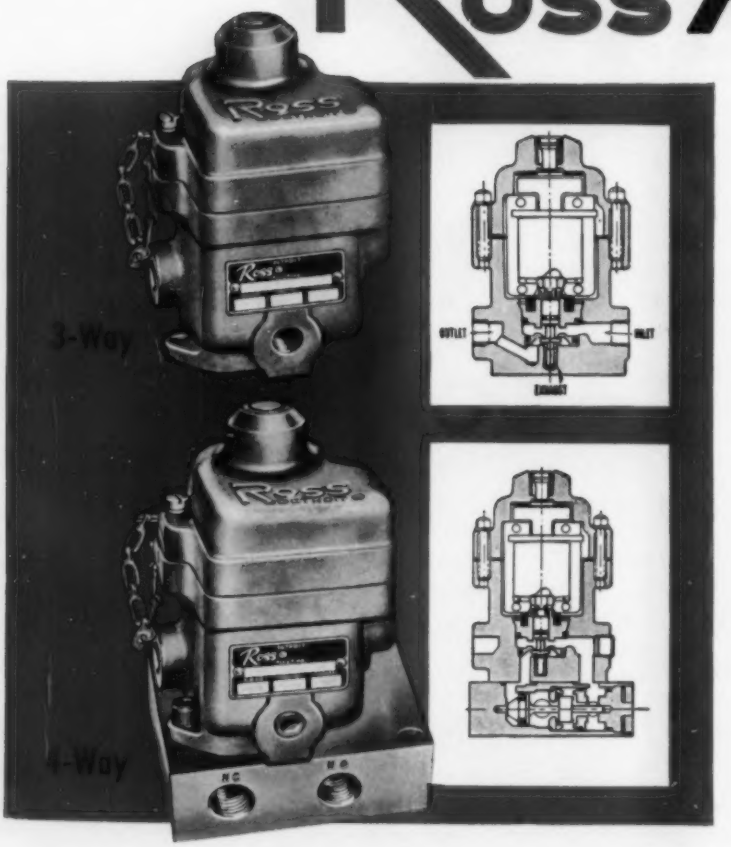
three design steps in nuclear subs

1 World's first atomic ship, the Nautilus, (1) is now almost six years old, traveled 62,500 miles on the original uranium core. Sargo (2) two years younger and 80 ft shorter, became our third North Pole visiting sub in February. Shown are two Navy Research Labs engineers at the iceberg detector aboard. A 35-ft radiometric sextant mast (3) of 19-10 stainless presented new problems in tolerances and strengths. It goes on Polaris-firing submarines . . . see page 3

Announcing

a new and better solenoid valve in the $\frac{1}{8}$" and $\frac{1}{4}$" size range

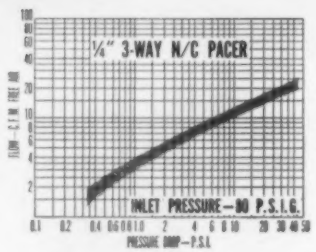
Ross PACER



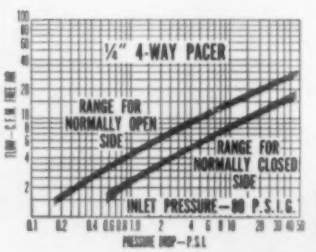
More life
More speed
More capacity
More value

Now you can have about three times more flow capacity-to-solenoid size than in most competitive valves. Needs just 7 watts of power yet minimum internal orifice size is full $\frac{1}{2}$". The PACER has short poppet travel, will cycle at better than 1000 cpm and meets JIC specifications. Lightweight, cast aluminum body means 3-way weighs just 20 ounces, 4-way just 28. Dust tight, liquid tight, can be manually actuated, has captive cover, is inoperative with cover removed, has integral wiring space. Why not test a PACER in your own circuit, just $18 for a 3-way, $26 for a PACER 4-way. Call your Ross representative or write for Bulletin 319.

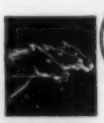
Pressure drop thru 3-way N.C. Pacer valve under steady flow conditions. Inlet pressure 80 psig. Data shown as a range rather than as absolute values due to variables such as barometric pressure, manufacturing tolerances, etc.



Pressure drop thru both N.C. & N.O. sides of 4-way Pacer valve under steady flow conditions. Inlet pressure 80 psig. Data shows ranges for each side rather than absolute values due to variables such as barometric pressure, manufacturing tolerances, etc.



STAY AHEAD
MODERNIZE



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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

May 2, 1960 Vol. 31, No. 18

FEATURED:

DEPARTMENTS:

INTERESTING TO NOTE 3
COMING NEXT WEEK 4
DEVELOPMENTS TO WATCH 6
WHAT'S NEW IN RESEARCH 9
FROM WASHINGTON 12
THE ENGINEERING WEEK 15
APPEARANCE DESIGN 26
READER TO EDITOR 28
COMING EVENTS 31
WHY NOT R&D? 32
HORIZONS 37
SIGNIFICANT COMPONENTS 64
DESIGN LITERATURE 71
REPRINTS 79
ADVERTISERS INDEX 81
READER SERVICE CARDS 83

ELECTRICAL ANALOG SIMPLIFIES HEAT-FLOW ANALYSIS . . . M Sklaroff
Simulator method predicts product behavior under complex conditions.. 39

WHICH COPPER ALLOY? . . . R J Christine, American Brass Co
For cold-heading applications, choice may be wider than you think... 42

MEN, METHODS & IMAGINATION . . . R M Koff, asst managing editor
Behind all three must be a strong management hand..... 46

9 WAYS—VULCANIZED FIBRE PARTS . . . E A Russel, Spaulding Fibre Co
The choice of shaping methods is explained by an expert..... 51

5 EXPERIMENTS IN TECH WRITING . . . J H Bloom and S A Goldstein
Tests of "good-writing rules" show some are true, others not..... 55

CENTRALIZED LUBRICATION? . . . E J Gesdorf, Eaton Mfg Corp
When it's preferable to manual methods; the 5 basic systems..... 56

6 INGENIOUS JOBS FOR ROLLER CHAIN . . . P C Noy
How this low-cost workhorse can be harnessed in variety of ways.... 60

FIELDS OF INTEREST REPRESENTED IN DEPARTMENTS:

MATERIALS: **New elastomers**—low-temp properties plus solvent resistance..... 8
Boron nitride being readied for structural jobs..... 8
Epoxy adhesive is stable at 392 F..... 67

MECHANICAL: **New nozzle, burner designs**—more heat at lower cost..... 6
This shock absorber needs no seals or lubrication..... 8
Governor detects speeds as low as ½ rpm..... 64
Exhaust air valve provides quick, complete venting..... 64

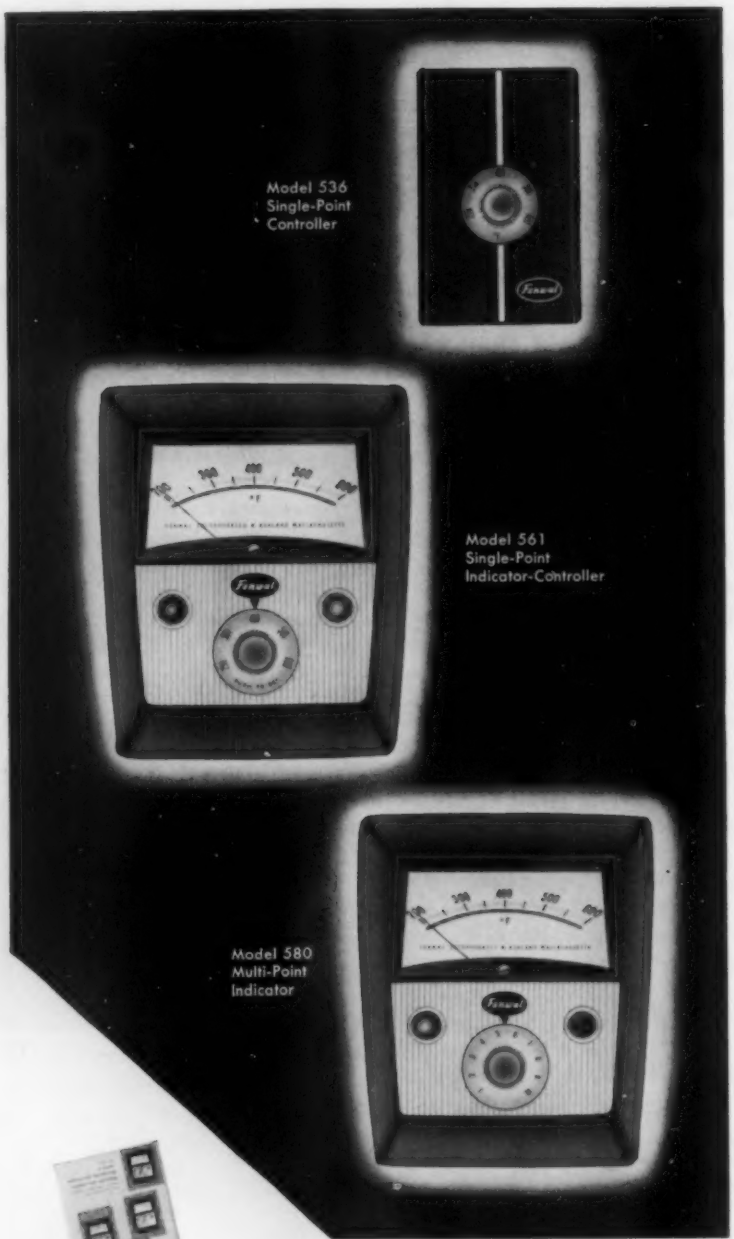
ELECTRICAL: **British offer new light-panels** and indicators..... 6
NASA contracts for space electrical generator..... 12
Ion-membrane fuel cell uses solid electrolyte..... 16
Miniature electrical switch costs one-third less..... 66

PRODUCT DESIGN: **Consumer products emphasized** in Japan..... 24
Europe's new cars feature compactness with comfort..... 48

PROCESSES: **An inventor's hard years**—the story of vulcanized rubber..... 3
Investment castings are getting new specifications..... 8

GENERAL: **Those new subs**—our cover story..... 3
Electra crashes being studied by aircraft industry..... 15
R&D spending still rising—6% more this year..... 17
California passes anti-smog bill but control poses problems..... 20

NOW... A Better Match for Temperature Control Requirements . . .



Here's the brand-new family of Fenwal Transistorized Temperature Controllers that lets you order *only* what you need. In addition, you obtain functions previously unavailable in thermistor controllers. These additions to the "500 Line" permit *precise* matching of control instrument to application over a temperature range from −50 to +600°F.

Thermistor sensors and rugged, reliable transistorized circuits assure long life and trouble-free operation . . . and eliminate lead wire problems. Every instrument is easily installed . . . in the plant or on the machine. Professionally styled cases and wide choice of colors blend with the most modern surroundings. And, best of all, advanced Fenwal design and production methods keep costs reasonable! Here are three examples:

The Model 536: reliable, single-point controller gives you these options: ON-OFF or proportioning control . . . set-point adjustment in the instrument or remotely located . . . indication as well as control . . . expanded scales for fine temperature adjustment. And you pay only for the option you need. Capacity of 10 amp/110 VAC and 5 amp at 230 VAC.

The Model 561: single point indicator-controller designed for panel mounting. Panel button permits meter display of temperature set point. Control and indication circuits are independent. Mirror-backed scale prevents parallax, tilted glass cover reduces reflection. Option of either ON-OFF or proportioning control. 10 amp/110 VAC relay capacity . . . insensitive to voltage fluctuations.

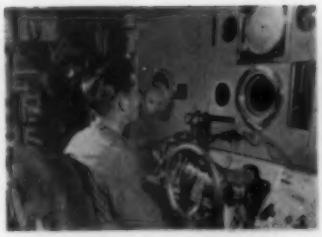
The Model 580: multi-point indicator permits "flick of a switch" indication of 2 to 10 temperatures controlled by up to ten Model 536 controllers.

These are just the high spots. For *complete* details on this versatile Fenwal family, send for bulletin MC-190, "Smarter Looking Smarter Acting Electronic Temperature Controls." FENWAL INCORPORATED, 24 Pleasant Street, Ashland, Mass.

Another example of how **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

INTERESTING TO NOTE

Those New Subs—Our Cover



The Nautilus (see cover), our first atomic submarine, is 320 ft long, displaces 3200 tons. She is a developmental boat, now far surpassed by the lighter and shorter Skipjack class (PE—Oct 26, p 115), and first of the subs really "flown" under water. The newer boats are controlled even more like a plane than Nautilus is. Sargo is of the Skate class—the first quantity-produced nuclear sub. It cruised 2744 miles under the Arctic ice pack in 15 days, surfacing at the North Pole last Feb 9. In our cover picture Arthur Roshon, head of the High-Resolution Sonar Branch, Navy Research Labs, operates the iceberg detector, while Fred D. Parker, project leader on the detector, looks on. . . . Both pictures are official USN photographs.

The third picture shows final polishing of a radiometric sextant mast for a not-yet-completed Polaris-type submarine. It is a hollow cylinder, flanged at one end, 34 ft 9 in. long, 18 in. OD, with 1⅞-in. nominal wall thickness. Originally, three methods of locating the sub's position were contemplated—conventional star-sighting, radiometric "sighting," and location by depth sounding. The choice was radiometric sighting, which is independent of weather or previous charting. While this method presents fewer problems than the other two, it is dependent upon a very high degree of accuracy in this mast, which relates the exact position of electronic receiving gear on the end outside the sub to associated equipment inside. This mast is centrifugally cast of a 19-10 stainless containing 2½% moly for higher corrosion resistance. Sandusky Foundry & Machine Co cast it in two pieces (one of them 23 ft-plus, with the integral flange), and Youngstown Welding & Engrg did the circumferential weld. Concentricity and straightness had to be held to 0.020 in. for the entire length of the cylinder, and end counterbores had only 0.005-in. tolerances. Surface finish was 16 rms on one counterbore, 32 on the entire OD. Edo Corporation was the contractor for this unit, serving General Dynamics as prime contractor for the submarine.

Goodyear's Hard Years

Many men have been obsessed by a single idea. Rarely, however, are they as stubborn as Charles Goodyear was.

In the early 1830s the rubber business in the US began to boom. Small companies were springing up in the East, caught

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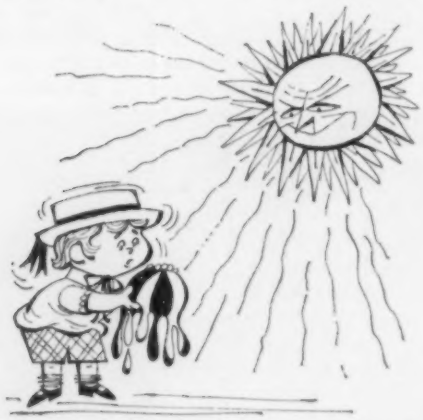
in an "India-rubber fever" as it was called. After several summers, however, most products made from rubber turned to a smelly, molten mass of goo. The industry was doomed unless rubber life could be improved. At this point, Goodyear, then a middle-aged hardware salesman,



stepped into the picture. He thought of rubber as leather that simply needed to be cured, and he honestly felt he could solve the problem in a matter of months.

Goodyear really knew nothing about rubber or chemistry. He approached the problem by trial-and-error. He first mixed crude rubber with turpentine, then salt, pepper, ink, witch hazel—and even cream cheese—all to no avail. He tried mixing his crude gum with some magnesia he found in the medicine cabinet. With this he was able to produce rubber samples firmer and smoother than anything made previously. Newspapers called him the man who would save the India-rubber industry. But they were a bit premature. Several weeks later he discovered that a drop of anything acidic was enough to neutralize the quicklime in the magnesia and ruin the rubber. Maybe pure quicklime was the answer. Goodyear tried that, but it destroyed the gum completely.

Years drifted by and Goodyear was still trying. His financial situation was desperate and at times he didn't have the money to buy a meal. At one point he found that sulfuric acid, added to the crude gum, produced a rubber better than anything he had so far developed. Goodyear applied for a patent and began producing sheet rubber. However, within two months he ran out of money.

He moved in with his brother at Woburn, Mass and continued experimenting. It was here that Charles Goodyear finally made the breakthrough which was to lead to vulcanization. He carelessly let a piece of acid-treated rubber come in contact with a hot stove, and found a portion of the rubber "was perfectly cured."

Although he had found the answer to his five-year search, his problems were just beginning. It took another two years of salesmanship to interest anyone in making rubber products again. Finally in 1841 he began to receive applications for licenses. In a short time he was able to make enough on royalties to pay all his debts ($35,000 worth). But he never made as much in royalties as he should have —he miscalculated and agreed on too low a figure.

He lived to see his process turn out more than 500 different articles selling for more than $8 million a year. Vulcanization of rubber was essential to the growing electrical industry. (Today it is being applied in fabrics as well, see p 51.) When he died in 1860, Goodyear was back in a familiar spot—$200,000 in debt. Seems he had turned his genius to promoting his process, but with a fanaticism that wasn't practical. —Benedict A Leerburger Jr

NEXT WEEK IN PRODUCT ENGINEERING

. . . **Pneumatics Simulates Electronics**
Using a pneumatic thyratron as an example, this article presents a dimensional analysis of all the essential units needed in actual applications.

. . . **Aluminum Diecastings**
A new alloy and an improved process promise to give them wider applications.

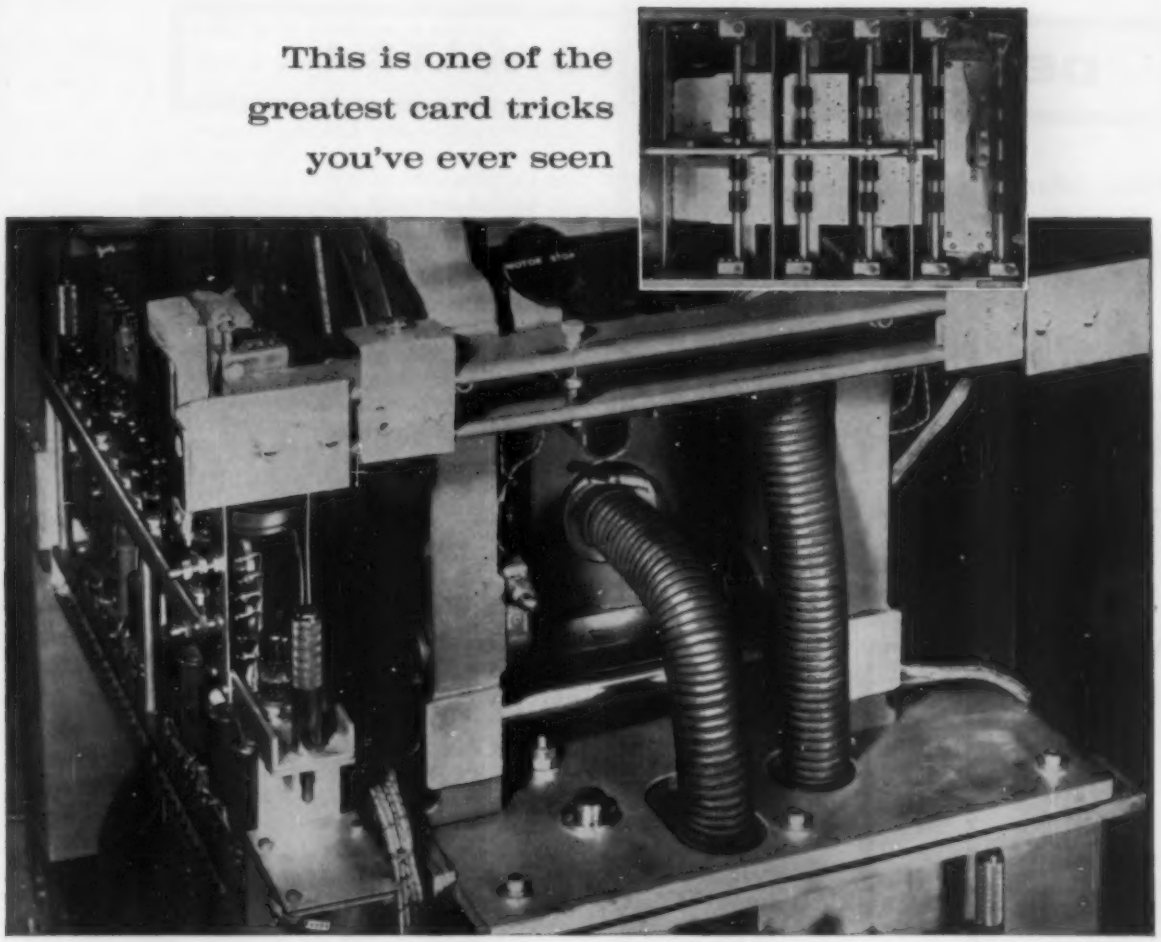
. . . **Predicting the Wear Life of Rolling Surfaces**
These equations assist in computing life expectancy of gears, cams, bearings, clutches and links.

. . . **Does Your New-product Idea Measure Up?**
This technique cuts the guesswork in making the "right" choice.

. . . **Finding Standard Deviation Faster**
Graphical method, using vectors, saves time and is as accurate as your plotting skill.

. . . **Fiber Stress in Helical Springs**
Aids calculation of springs 1-in. to 30-in. mean coil diam with 1/16 in. to 4-in. bar section.

This is one of the greatest card tricks you've ever seen



This is how Flexible Tubing helps Univac* designers bring it off

In the Remington Rand Univac, Solid-State Computer, the high-speed reader reads 450 punched cards *twice* every minute, and compares the two readings on every card.

Cards must be positioned exactly right in the feeder — and held there! Strong suction does the trick . . . strong suction provided through two lengths of Flexible Tubing Corporation's noncollapsing "Flexflyte." A third length gives the high speed reader a rugged, vibration-free connection between the suction turbine and the distribution manifold. The great flexibility and toughness of "Flexflyte" permits it to stand up under the constant movement of the picker knife.

Chances are you don't design high-speed computers. But if you work on any kind of original equipment where the handling of air, liquids or light solids is a design problem, there's a Flexible Tubing product that can do the job! You can choose fabrics, coatings, diameters and sizes to fit your specifications. Flexible Tubing is now being used on a wide range of original equipment — diesel engines, farm combines, industrial gluing machines, television transmitters, vacuum cleaners and many other products.

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DEVELOPMENTS TO WATCH . . .

British offer new light-panels and indicators

Electroluminescent lighting devices of both the "organic" and ceramic types are being developed by Thorn Electric Industries of Middlesex, England.

The organic-dielectric lamps are glass-base panels, treated with tin compounds at high temperature to produce a transparent but electrically conductive surface that forms one electrode of the unit. On top of this is a phosphor-containing hard plastic layer about 0.0005 in. thick; and superposed on it a thin layer of high-dielectric plastic.

A back-electrode, made of a semiconductor with "self-healing" electrical properties, completes the assembly.

The ceramic units are metal-based, with the ceramic serving as carrier for the phosphor. In other respects, they are similar to the ones described above.

First commercial units will be green in color with a maximum brightness at 230 v (50 cps) of about 3 ft-lamberts. Current consumption at that level is about 0.1 milliamps per sq in. Life expectancy is in the 40,000-hr range.

Note: For information on how such panels may be used, and on US developments in this field, see *PE—Sep 15 '58, p 74.*

New nozzle and burner designs—more heat at lower cost

A constant-flow nozzle insensitive to viscosity and temperature changes, and delivering fuel at the same rate throughout the operating period . . .

A burner that "recycles" flame . . .

Another burner that has no moving parts and uses steam instead of air to draw in heating oil . . .

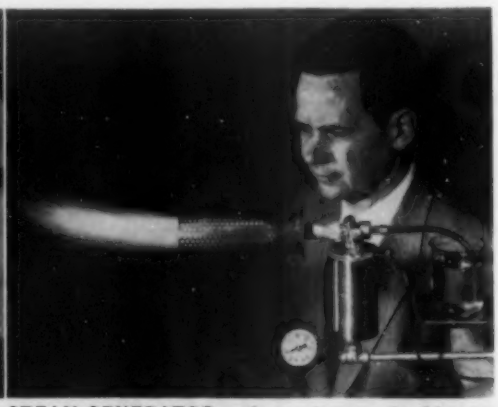
These are among the new devices being developed by Gulf Oil Co for converting fuel oil into heat. The nozzle is already being field-tested, but the burners (see photos below) are still in the R & D stage.

One burner (left, below) consists of an air-aspirated nozzle, a small low-pressure rotary air pump, a perforated flame tube, and an igniter. Oil is drawn in by the air, and then ignited as the mixture sprays from the nozzle. The flame tube aids combustion by bending the flame into a "ring of fire," thus serving as a recycling device.

The new design, says Gulf, achieves much more efficient combustion by virtue of more thorough mixing of air and fuel; and it requires much less servicing. Its air-aspirated nozzle is relatively larger than conventional design and much less likely to clog or become caked. Furthermore, it is adaptable to existing furnaces, boilers, water heaters, air conditioners, and home incinerators.

The other new burner is basically similar to the air-aspirated unit, except that steam is used as the carrier. Eventually, Gulf believes, it may even be possible to eliminate the nozzle by using an electrostatic field to atomize the oil.

AIR-ASPIRATED BURNER has perforated tube that "recycles" flame for better combustion.



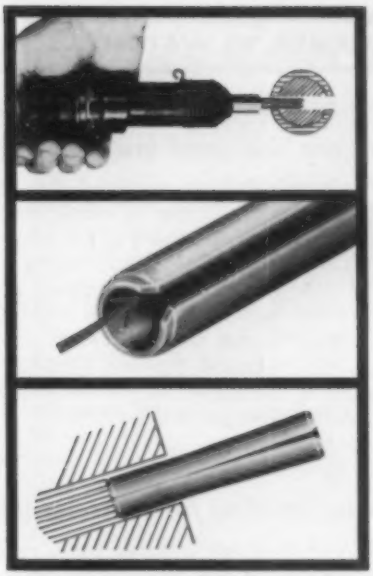
STEAM GENERATOR replaces air pump in this new burner design. It has no moving parts, should require minimum maintenance.

Rollpin won't mushroom or telescope

There are no installation or removal problems with Rollpins. Because of their column strength they can be readily driven with a hammer, removed with a punch without bending or collapsing. Of course production line tooling such as an arbor press, a pneumatic hammer . . . even a hand riveter . . . is ideal for Rollpin insertion.

Rollpin won't damage or enlarge hole

With smoothly chamfered ends providing an easy lead-in, Rollpin is compressed into complete conformity with the shape of the hole. The exclusive, v-shaped, coped corner design eliminates possibility of damage to the hole walls. They prevent any possible scoring action as the pin is driven and insures uniform insertion and removal characteristics. The benefit to you: the same pin can be reused in the same hole.



ONLY ROLLPIN OVERCOMES ALL THESE FASTENING PROBLEMS!

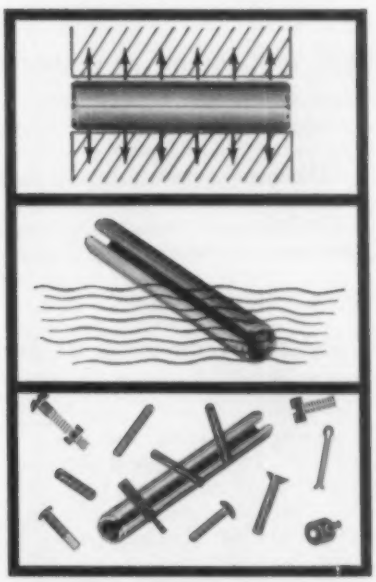
Rollpin exerts EVEN pressure

In some fasteners, only a portion of the fastener shaft does the actual holding. Rollpin, however, exerts a uniform pressure around the entire inside surface of the hole—giving you maximum holding power and superior resistance to vibration.

Split tubular construction assures uniformity of heat treatment that is difficult to obtain with spiral types of pins; there is an even plating "throw" inside the pin as well as outside for superior corrosion protection.

ONE TYPE of Rollpin does EVERY TYPE of job

Versatile Rollpins will replace at least 12 different types of fasteners. Every Rollpin can be hopper-fed, can be installed with a single operation. They are available, from stock, in a wide range of lengths and in diameters from 1/16" to 1/2". Manufactured from carbon or corrosion resistant steels and beryllium copper.



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New elastomers combine good low-temp properties with solvent resistance

Complex fluorine copolymers that are elastomeric at high molecular weights, are nonflammable, and offer "a unique combination of good solvent and chemical resistance along with serviceability at low temperature," are being developed by the QMC R & E Command, and Minnesota Mining.

These are materials containing no hydrogen, and having an entirely new type of molecular structure, with an N-O-C-C backbone. Furthermore, say J. C. Montermoso of QMC and G. H. Crawford and D. E. Rice of Minnesota Mining in a report prepared for the American Chemical Society, the basic structure of these fluorocarbon-nitroso rubbers can be modified to provide a wide range of polymers that differ considerably in their physical properties.

Boron nitride being readied for structural jobs

As a structural material, boron nitride looks like an excellent answer to the twin problems of heat and corrosion in pumps handling liquid metals, rocket engine parts, and nuclear reactor components, say I. M. Sleptsov and G. V. Samsonov of the Ukranian Academy of Sciences. They believe the material will also prove to be a good base for high-temperature lubricants, and for coating automatic welding electrodes.

Other boron nitride applications under study in the USSR range from semiconductors to insulation for HF vacuum induction furnaces. This nitride is particularly good for the latter, the Ukranians claim, because it is not heated by induction currents.

Investment castings are getting new specifications

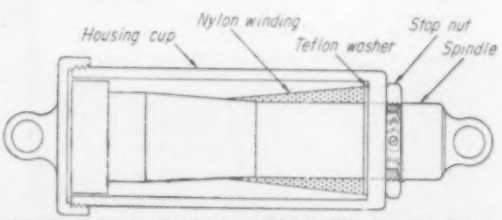
Improvements in alloying additions and investment-casting techniques for 17-4 PH stainless have made it possible to revise specifications for these materials, say WaiMet Alloys and Armco Steel.

Minimum elongation can be doubled, since tests show all samples in the 11 to 16% range.

WaiMet and Armco are readying modifications for AMS specification 5355, based on changes in chemistry and aging temperatures.

This shock absorber needs no seals or lubrication

A shock absorber that uses a nylon fiber coil as the primary operating mechanism, and can be made in a wide range of sizes for a wide variety of loads, has been developed by Northrop Div of Northrop Aircraft Inc.



CONE-IN-COIL SHOCK ABSORBER is simple in design, can be used for earthmoving equipment, truck and rail shock mounts, instrument assemblies.

The device consists of a spindle, cylindrical at the ends and conical in the center, around which the nylon fiber is wound in coil form. When force is applied, drawing the cone into the coil, the coil expands, putting a tensile stress on its filaments.

Since this stress is dependent on degree of taper of the spindle, cross-sectional distribution of the fiber, and friction between coil and spindle, an almost infinitely variable series of shock absorbers can be designed. Furthermore, says Northrop, operating range is −65 to 350 F or more, no seals are necessary, and there should be no maintenance requirements other than a cursory check for external damage.

—ARG

WHAT'S HAPPENING IN RESEARCH . . .

Ceramics tested for rolling-element bearings

Crystallized glass ceramics don't have the load-carrying capacity of steel balls, and their fatigue life in the 700-F range is not as high as might be expected; but, says NASA's Lewis Research Center, they may well prove useful in low-load, short-duration applications where an operating temperature above the limit of steel is the paramount design consideration.

Summarizing tests of ½-in. Pyroceram bearing balls in a 5-ball fatigue tester, T. L. Carter and E. V. Zaretsky of Lewis say:

- The room-temperature load-carrying capacity of the ceramic is approximately one-fifteenth that of M-1 tool steel balls.
- Fatigue life of the ceramic varies inversely with approximately the 11th to 13th power of contact stress. (Steel normally has an inverse 9th to 10th-power relation.)
- Degree of structural homogeneity may be an important factor in life of crystallized-glass ceramic-bearing materials; and differences in life between specimens nominally differing only as to finish indicate that finishing methods may also have an important effect on fatigue life of the ceramic.
- Type of lubricant appears to have a significant effect on rolling-contact fatigue life. For instance, better life is obtained with paraffinic mineral oil than with sebacate diesters. This correlates well, the researchers note, with effects of lubricant viscosity and base stock previously observed with steel balls.

Results of the initial studies have now been published by NASA, and are available as Technical Note D-259.

New concept simplifies that puzzling pH

The strange-looking symbol of acidity, pH, which has the distressing characteristic of going down when it should go up, can be more easily understood and applied, suggests F. E. Crane Jr of Rutgers U, through use of a concept he calls "cH".

The trouble with pH, is that it was defined as the negative logarithm of the hydrogen-ion concentration, so that when the concentration is greater than 1, pH is a negative number. Why not, he suggests, take a positive approach?—do it with a new concept, cH, defined as equal to the log of the hydrogen-ion concentration plus 16 (the atomic weight of oxygen, and the basis of the chemical atomic-weight scale). This way, there is a direct relationship between the index and the hydrogen-ion content, and the index is positive unless alkalinity is high.

At the very least, such a concept would be most helpful in teaching, says Crane because cH = 16 − pH.

Aluminum-powder products are good—but

Aluminum parts made by powder metallurgy are indeed stronger at elevated temperatures than conventional wrought alloys. But they are not quite as strong as previous reports would indicate, says W. H. Friske of Atomics International.

A series of tests made under AEC sponsorship indicates APM (aluminum powder metallurgy) or SAP (sintered aluminum powder) parts are strengthened by the aluminum oxide dispersions they contain, but tensile properties at 800, 900, and 1000 F are some 10% lower than published values: 6900 to 11,000 psi as compared with 7500 to 12,000. Creep-rupture strength is also significantly (10 to 20%) lower at 900 F, and is reduced still further by cold working. However, at least one of the APM alloys (M257) showed even greater ductility than expected. An interim report on the studies (NAA-SR-4233) has been prepared and for $1 is available through OTS, Dept of Commerce, Washington 25, DC.

briefs . . .

Flash X-ray studies of motors, generators and bearings at motion picture speeds, and stroboscopic examination of hermetically sealed units will be possible, says Zenith Radio Corp, with a newly developed hot-cathode tube. It's still in the prototype stage, but sounds like a valuable aid.

A rate equation for oxidation of metals that form volatile oxides (molybdenum, tungsten, tantalum, columbium) has been developed by J. L. Modisette and D. R. Schryer of NASA's Langley Research Center. As they point out, because these oxides vaporize below the melting points of the metals, they provide little protection. The rate of oxidation, then, is a function of the concentration of oxygen in the gas at the surface and the diffusion of fresh quantities of oxygen to the surface. Tests on molybdenum at temperatures in the 2000 to 3000-F range show good agreement with values predicted on this basis.

A report showing derivation of the equation and detailing the tests used to check it is being made available through NASA, Washington 25, DC, as Technical Note D-222. —ARG

New aid for crystal studies

For metallurgical and crystal research, Seton-Creaghe Engineering Ltd of London, England is introducing this attractive-looking instrument, which makes it possible to examine the crystal structure of a specimen in any plane simply by adjusting the goniometer. Variable-speed motors permit rotation and reciprocation of the specimen holder, and a motor can also be provided to operate the goniometer ring. Price is about $5000.

MULTIPLANE X-RAY DIFFRACTOMETER, designed in England, is versatile, relatively low in cost.

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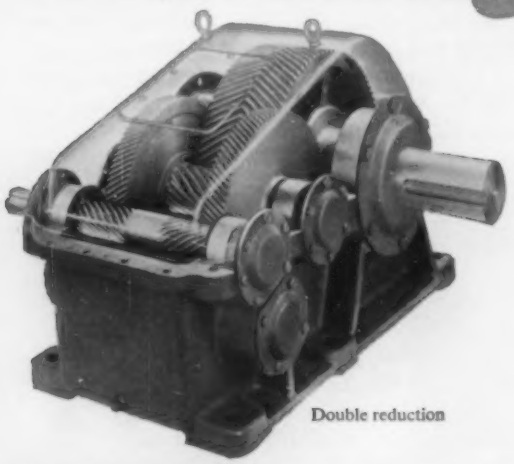

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FROM WASHINGTON . . .

NSF verifies R & D spending spurt

The National Science Foundation's voluminous and detailed report, "Science and Engineering in American Industry, 1956," has just been released. A comparison of this report with a similar study by the foundation for 1953, yields a striking picture of the growing volume of work being done in US industrial labs. Here are some of the salient findings:

• **Cost of R & D conducted by manufacturing and other industries rose from $3.5 billion in 1953 to $6.2 billion in 1956.** (A McGraw-Hill survey, reported on page 17, indicates that industrial R & D will hit $9.6 billion this year.) The federal government was primarily responsible for this trend. During the interval, federal contracts for R & D in industrial labs rose 126%, reaching $3 billion in 1956. In the same period company-financed research climbed 45%, to slightly more than $3.2 billion.

• **To carry out this research, industry employed 223,000 scientists and engineers and 396,000 other persons.** Engineers accounted for 151,000, or about two-thirds of the professional persons working on R & D projects. This represents a gain of about 45% over the 1953 survey.

• **The foundation also learned that basic and applied projects accounted for about a quarter of the industrial R & D conducted in 1956.** Cost of basic research was $244 million (4% of the total); cost of applied research projects amounted to $1.2 billion. Development activities accounted for the remaining $4.8 billion.

The survey, which also contains fairly detailed figures on R & D done in various industries and in companies of various sizes, the cost of R & D per technical man, and data for commercial labs and trade associations, is available through the US Government Printing Office, Washington 25, for 70¢.

NASA contracts for space electrical generator

A 700-lb, sun-powered electrical generator, designed to produce 3000 watts of electrical power, is under development for the National Aeronautics and Space Administration. Designed to fit the nosecone of a Centaur or Saturn rocket, the Thompson Ramo Wooldridge Tapco Group design is expected to last for one year.

As now conceived, the generator, known as Sunflower I, will include a petal-type solar collector that will unfold in space to a diameter of 32 ft. The collector will concentrate sun's heat on a boiler containing liquid mercury. The resulting mercury vapor will drive a turbine that generates electricity. Vapor will be condensed and reused. The device will also include a heat-energy storage unit to permit power output when the craft is in the earth's shadow.

NSPE requests amendment to labor act

The 52,000-member National Society of Professional Engineers is asking the Labor Standards Subcommittee of the House Education and Labor Committee to consider amending the Fair Labor Standards Act. They want the same recognition for professional engineers that is granted doctors and lawyers.

Doctors and lawyers are placed in the professional-employee group by virtue of their license. Professional engineers are not. The Administrator of the wage-and-hour law requires licensed engineers to pass a "salary test"—to be classed as a professional, an engineer must be earning $95 per week.

The Administrator has declined to accept a professional license as he does a doctor's or lawyer's license. Hence, the engineering society feels that "since every state legislature and the Congress have declared the professional status of licensed engineers" there is no justification or warrant for the Administrator to ignore that fact when requiring the salary test of licensed PE's.

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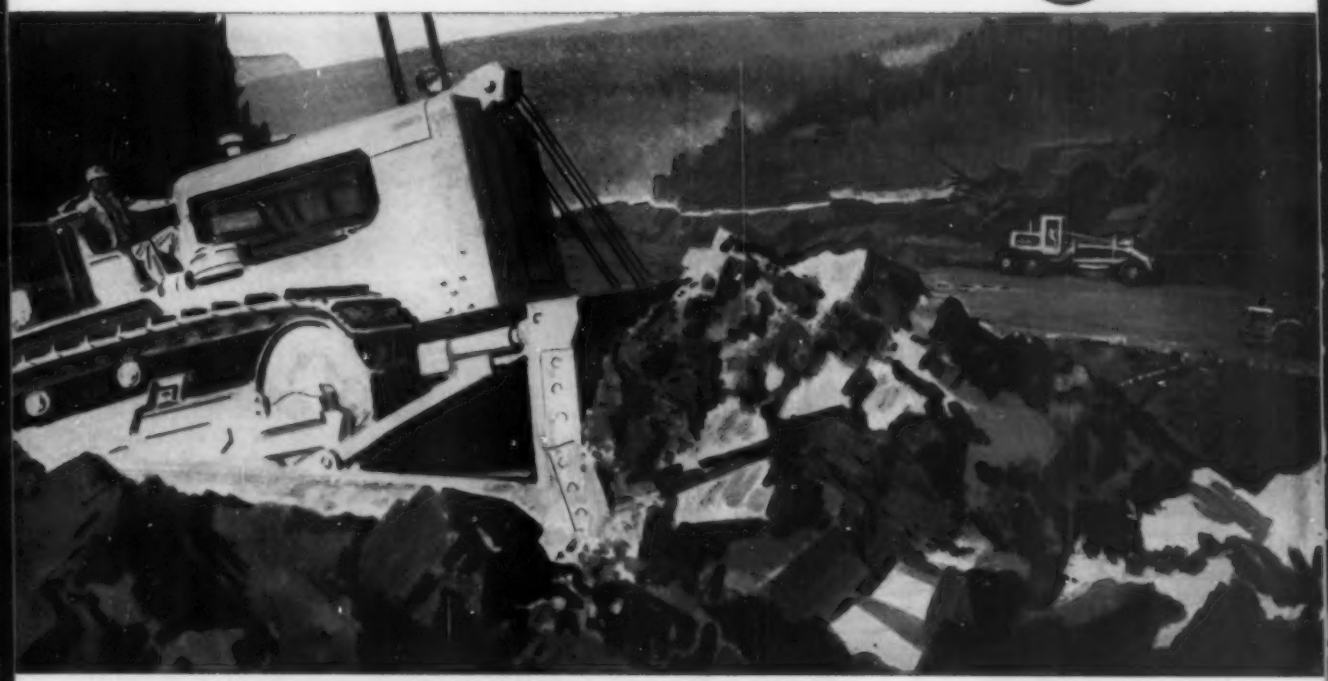

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"...NEW MANUAL EXPANDS INFORMATION ON MINIATURE & INSTRUMENT BALL BEARINGS..."

By **GEORGE HAMPSON**, *Vice President-Sales, New Hampshire Ball Bearings, Inc.*

"... this 'Design & Purchasing Manual' replaces the first-of-its-kind 'Technical Data and Catalog' book NEW HAMPSHIRE published in 1957. As the 'Technical Data' (black cover) was then, we believe the 'Manual' (green cover) is now, the most complete source of information on miniature and instrument ball bearings in print. About 50 pages larger than the old book, the 'Manual' was expanded that much to include information developed since 1957 on ordering, maintaining, fitting, lubricating and testing miniature bearings."

QUALITY — AND ASSURANCE

"The significance of ABEC Class 7 tolerances to running quality of instrument bearings is covered in one section with a brief, to-the-point explanation of how improved bearing geometry helps the design and quality control engineer. A pictures-and-words story describes NEW HAMPSHIRE's Quality Assurance by which this high standard for miniature bearings is maintained in production. The equipment used, and how used, is fully described. Testing geometry and finish, cleaning and lubricating, functional testing of bearings, and metal research are some of the subjects covered."

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"An even easier-to-read tabulation form is used to list NEW HAMPSHIRE Bearings in Bore/OD/Width sequence for quick identification and selection when ordering or writing specifications. Three hundred seventy bearings are so listed, including NEW HAMPSHIRE wafers, the narrowest shielded retainer bearings possible for given Bore/OD combinations, and developed especially for manufacturers of synchros, servos, small motors, potentiometers, miniature gear trains, and other products where space-for-bearings is a problem."

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"The 'Design & Purchasing Manual' includes a section on Designation, Packaging and Marking in which NEW HAMPSHIRE Bearing number symbols are explained, methods of packaging available from NEW HAMPSHIRE are described, and materials identification codes listed. Study of this section can work savings of money and time by minimizing the necessity of returning mistake-ordered bearings. In addition, simple HOW TO ORDER instructions are included on every page of bearing tabulations.
A Table of Weights is provided to assist those responsible for systems design and planning to compute weights of the NEW HAMPSHIRE Bearings specified and included."

ENGINEERING BULLETINS EXPANDED

"The Engineering Bulletins have been expanded and brought up-to-date to inform designers, engineers and quality control personnel of the latest developments related to Lubrication, Load Ratings, Fits, Speed, and other factors affecting performance and life of instrument bearings. There are now 22 Bulletins on as many subjects, including the two most recently developed, Duplex Bearings, and Bearing Roundness —one hundred seventeen pages of technical information on miniature and instrument ball bearings compiled and written by Bearing Engineers."

REGISTERED COPIES AVAILABLE

"The 'Design & Purchasing Manual' should be in the library of every designer, draftsman and buyer specifying or purchasing miniature and instrument ball bearings. Each copy is registered to its recipient. Your name and title sent to us on your company letterhead will bring your copy to you by return mail."

NEW HAMPSHIRE BALL BEARINGS, INC.
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THE ENGINEERING WEEK

Lockheed, FAA, CAB, Others Seek Cause of Electra Crashes

Los Angeles—One of the most thorough engineering investigations in the history of the aircraft industry is being conducted to find out whether some mechanical or structural failure has contributed to each of the two recent crashes involving a Lockheed Electra. Although more extensive than past investigations—this one even has the Weather Bureau studying the mysteries of invisible turbulence at high altitudes—it is probably no more intensive than other investigations . . . of the piston-driven Lockheed Constellation, Douglas DC-4 and DC-6 airliners, or the 707 jet (*PE*—Aug 17 '59, p 25).

True, the Federal Aviation Agency emphasizes that the Electra, structurally and mechanically, exceeds FAA requirements by ample margins. But, a spokesman for the agency conceded, present requirements may not be tough enough.

WHAT'S BEEN DONE

On March 22, five days after the Tell City, Ind crash of a Northwest Airlines Electra, Elwood R. Quesada, FAA administrator, called a special meeting of Lockheed and Allison personnnel, plus representatives of all airlines using the turboprop aircraft. He felt there were enough similarities between the two accidents (with the cause of the Braniff crash at Buffalo, Tex, still undetermined) to indicate possible mechanical failure as a common cause. The scattering of wreckage over a distance of several miles in both cases gave some credence to one theory that a propeller reversed and the sudden jolt tore off a wing. The left wing came off early in the disintegration of the Electra in Texas, and the right wing off the plane that crashed in Indiana.

Industry generally feels the two accidents are dissimilar enough to make a common cause unlikely. Investigation seems to indicate that a propeller reversal did not occur in the Texas crash; that the high-altitude air turbulence in the area of the Indiana crash was not duplicated at the time of the Texas crash.

However, all at the meeting went along with Quesada on his decision to take a thorough second look at the Electra and with the drastic operating limitations that were ordered. Aircraft speed is presently restricted to 225 knots average, 245 knots maximum, and FAA noted that the lower speed would permit a rapid slowdown to safe "rough air" penetration speed if turbulence was encountered.

In addition, FAA ordered all autopilots deactivated until checked for conformance to the latest Lockheed service bulletins. FAA emphasized that this is being done because the autopilot is a component that can be isolated from the rest of the plane for separate investigation, and not because of any indication of autopilot malfunction.

There will be additional inspections of all "suspect areas" of all Electras in service; particularly after hard landings or rough flights.

Lockheed has agreed to undertake a complete reevaluation of the plane. Most of this, says FAA, goes far beyond existing regulations.

MONEY NO OBJECT

Time rather than money is the critical factor in the programs now underway by Lockheed, FAA, NASA, Northwest, and the CAB.

Lockheed's program is the most extensive of the group and involves:

- Complete flight testing of company-owned test plane with extra accelerometers, strain gages, and other instruments for structural measurements during level and maneuvering flights. This also includes additional gust and maneuver testing which should reconfirm the plane's certification design information.
- Engine testing has already turned up one problem that has been minimized by a design change. High propeller stresses have been reduced by increasing the engine nacelle angle by 3°. The FAA reports that nothing points to the engines, props or gearboxes as a source of trouble, but are checking vibration in this area as part of a general review. Electra's engines and props are the biggest ever put on a commercial airliner and low propeller speed—1200 rpm—combined with 14,000 rpm engine speed might cause an unknown vibration factor.
- Autopilots and control systems are to be completely evaluated with a series of new induced-failure tests and multiple-failure experiments.
- Complete structural tests-to-destruction of the wing and nacelle are planned as a final step in the program. FAA says, "There is virtually no doubt of the basic strength of these structures, but we are leaving no stone unturned." The Electra, like other transports, is designed with "fail-safe" regulations. This requires that the structure be capable of supporting ⅔ of its design load after one of the major structures has failed.

A wing, for example, can develop a main spar failure. Some deflection is permissible because the load is redistributed through the remaining

sound structural members, but it must support ⅔ of the design load. With the Electra, wing sections are capable of supporting the full design load with a main element lost, and ⅓ of the load with two main elements lost. FAA had foreseen the possibility of problems due to high-speed flight; it had recommended and the manufacturer had used an ultra-conservative structural design approach.

Northwest Airlines has turned over to Lockheed the sister ship of the one lost in the Tell City crash for a complete tear-down inspection.

NASA is reviewing load distribution of the Electra, and tests to obtain more complete data on effects of gusts and turbulence will probably be made in one of NASA's wind tunnels.

CAB, meanwhile, has recovered most of the pieces of the Braniff plane for reconstruction and investigation. At Tell City, they were less fortunate, as most of the fuselage and tail section were buried and fused together in the pit dug by the impact. A point of similarity already noted: fuselage of both planes remained relatively intact after separation from the wings.

Weather Bureau is increasing its efforts to study clear-air turbulence. According to a bureau spokesman, the general conditions under which clear-air turbulence occurs are known, but some way must be found to pinpoint such turbulent areas and to pass this information along to pilots.

WHY AN ELECTRA PROBLEM?

That the Electra should run into problems that military turboprop planes haven't met seems unlikely until utilization is considered. Of the 174 Electras ordered by commercial airlines, 137 have been delivered and put into immediate, round-the-clock service on heavily traveled routes. Rate of utilization of military crafts is only a fraction of that of a new airliner.

For example, while there is no basis of direct comparison, FAA points out that the amount of performance and maintenance information available on Boeing's 707 far exceeds what is known about the KC-135.

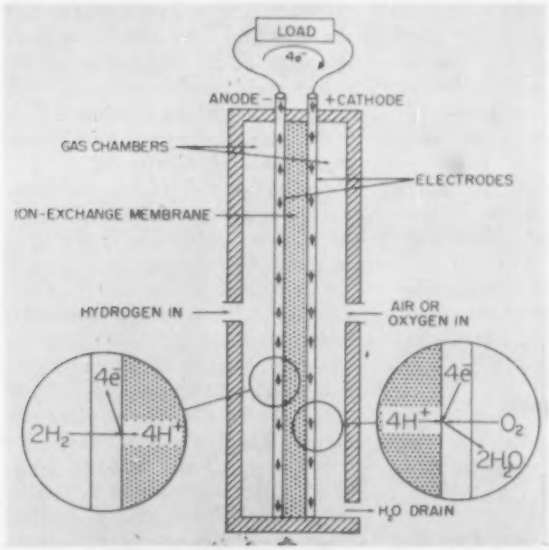
Electras were bound to have problems and are likely to encounter minor new ones because the plane's excellent short-run capabilities have resulted in its being subjected to more takeoffs, climb-outs, and landings.

Ion-membrane Fuel Cell Uses Solid Electrolyte

LYNN, MASS.—A fuel cell power source that can be mass-produced and may become an off-the-shelf military item is being delivered by General Electric's Aircraft Accessory Turbine Dept to the Navy's Bureau of Ships and the Army Signal Corps. The 30-lb unit will supply power for portable radar sets. It can produce 200 watts of 24-v dc for 14 hr, and is considered a replacement for 55-lb engine generators or 80-lb secondary batteries.

If operated continuously over longer periods of time, the unit requires only additional increments of fuel. For example, to provide full power at a remote site for one week, only 72 lb of fuel would be needed. This is opposed to transporting almost half ton of freshly charged batteries to the site.

Heart of the unit is a series of 30 ion-membrane fuel cells developed by GE's Research Laboratory. Each cell is an 11-in.-sq assembly about ¼ in. thick. Consuming only oxygen from the air and hydrogen produced by decomposition of a metal hydride "fuel," an individual cell is silent, odorless, has no moving parts, operates at ambient temperature and pressure, requires no complex control system, and uses a solid electrolyte rather than a caustic one. ■



FUEL CELL OPERATION is based on release of hydrogen by decomposition of metal hydride in contact with one side of plastic sheet; oxygen in air contacts other side. Hydrogen breaks into electrons and positively charged hydrogen ions. Electrons travel from one electrode to other; hydrogen ions move through membrane to combine with oxygen.

SUITCASE-SIZE fuel cell powerpack is easily handled by one man. Operating unit (shown here in mockup) has replaceable canister inside perforated guard at top to produce fuel for 14-hr unattended operation. Quick-disconnect fittings permit rapid connection of new canister as fuel is used. Casing is cut to show fuel cell stack.

R&D Spending Still Rising–6% More This Year

NEW YORK–American industry plans to do $9.6 billion worth of R & D work this year–6% more than last year. And it expects to raise commitments to $10.7 billion by 1963. (These figures represent research that will be carried out in industrial labs, some of it financed by government.) Although the volume of funds allocated to research is not increasing as rapidly now as a few years ago (it rose 11% between 1958 and 1959), technology is still a growing industry. These are key findings of the 13th Annual Survey of Business Plans for New Plant and Equipment just released by the McGraw-Hill Department of Economics.

The trend toward more R & D, the survey finds, is universal in all industries–except aircraft. Manufacturers of missiles, aircraft and parts, whose R & D is heavily supported by government, have apparently reached a plateau. In past years, R & D in this industry has shown one of the highest rates of growth. But, if survey results are borne out in practice, aircraft R & D may be of slightly diminishing importance in the future. Last year, aircraft manufacturers accounted for 36% of all R & D; this year, they will probably account for 34%; and in 1963, possibly only 30%.

It seems likely that the trend toward more industrial R & D will continue–at least as long as research offers the prospect of new products. To a query on how they determine the level of their research budgets, nearly half of all companies reported that their new-product plans are a determining factor. (For details gained from the survey, see the accompanying tables.) This suggests that, in many companies, R & D is geared to the longer range potentials of engineering, and is relatively independent of temporary business fluctuations such as sales and profits. This is especially true in the transportation-equipment industry and some metalworking fields such as autos and machinery.

The companies expect their new-product development programs to have considerable impact on company sales in the next few years. For manufacturing as a whole, 12% of the 1963 sales are expected in products "not made in 1959 or sufficiently changed to be reasonably considered as new products." Especially vigorous product development is now foreseen in the metalworking industries: transportation equipment (including aircraft, ships, railroads, etc.), electrical machinery and machinery.

IMPACT ON CAPITAL SPENDING

A prime purpose of the McGraw-Hill survey is to determine the capital-investment plans of American business for the present and the few years immediately ahead. Many economists believe capital spending is just about the most important indicator of business prospects. When companies are building plant and equipment, the heavy basic industries are normally busy and offering wide employment opportunities. The survey this year found that manufacturing industries will invest $15.2 billion in new plant and equipment–26% over last year.

continued on page 20

R & D Expenditures Continue Up

(Million of Dollars)

Industry	Spent in 1959	Planned for 1960	Planned for 1963
Primary metals	138.1	167.1	198.8
Machinery	678.0	745.8	880.0
Electrical equipment	1607.9	1800.8	2161.0
Aircraft and parts	3250.3	3250.3	3250.3
Fabricated metals & ordnance	223.0	263.1	336.8
Prof & sci instruments	382.9	413.5	512.7
Chemicals	661.8	714.7	850.5
Paper products	83.4	76.7	95.9
Rubber products	89.3	95.6	111.9
Stone, clay & glass	73.6	83.9	104.9
Petroleum products	300.7	315.7	347.3
Food & kindred products	97.2	110.8	140.7
Textiles & apparel	34.6	35.3	41.3
Other manufacturing*	1055.6	1066.2	1194.1
ALL MANUFACTURING	8656.4	9139.5	10,226.2
Nonmanufacturing	370.6	415.1	485.7
ALL INDUSTRIES	9027.0	9554.6	10,711.9

* Includes autos, tobacco, lumber and wood products, furniture, printing and publishing, transportation equipment other than aircraft and autos, and miscellaneous manufacturing industries.

New Product Plans Stimulate R & D in Most Firms . . .

Industry	Number of Companies, in %, and Factors Affecting Their R & D Spending: Current Profits	Capital Investment Plans	Current Sales	Plans for New Products	Other
Iron & steel	21%	5%	32%	26%	16%
Nonferrous metals	12	0	25	44	19
Machinery	12	3	22	55	8
Electrical machinery	11	6	26	43	14
Autos	7	0	36	57	0
Transportation equipment	0	0	28	72	0
Other metalworking	18	0	26	47	9
Chemicals	11	6	29	42	12
Paper & pulp	18	0	18	50	14
Rubber	14	0	28	58	0
Stone, clay & glass	6	0	44	28	22
Petroleum & coal products	17	0	0	50	33
Food & beverages	12	3	21	52	12
Textiles	16	3	19	49	13
Miscellaneous mfg	21	0	32	38	9
ALL MANUFACTURING	13	2	26	48	11

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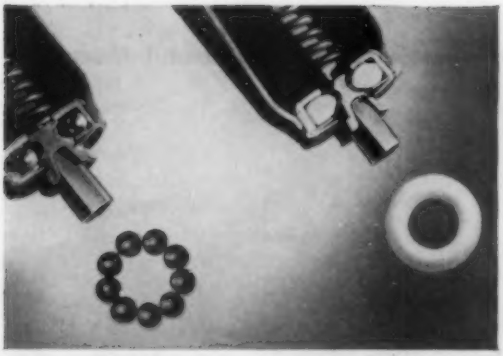
a new engineering material offering the user distinct performance and cost advantages in many applications once reserved for metal

Today, in hundreds of products, "Delrin" acetal resin is being used where die-cast zinc and aluminum, cast and machined brass, stainless steel and cast iron were once considered "standard". For good reasons, too: in "Delrin", these products work better, cost less to make, or both. On the opposite page, you'll find three typical examples.

The performance advantages offered by "Delrin" are based on its unique combination of properties that frequently permits parts reductions through design of multi-function parts. "Delrin" has the stiffness to remain rigid in large sections, the tensile and flexural strength to withstand high-stress loadings, the dimensional stability to hold close tolerances and the frictional properties to operate usually without lubrication. And these properties are retained even under exposure to wide variations in temperature, humidity, solvents and stress.

The cost advantages offered by "Delrin" stem primarily from its ease of fabrication, via injection molding or extrusion. These processes permit economical mass production. The need for finishing operations is usually eliminated. Part-to-part uniformity minimizes rejects. Assembly can be simplified by joining with mechanical fasteners, spin welding, snap or interference fits. "Delrin" is available in integral colors, and varied surface effects can be achieved by texturing, vacuum metalizing or painting.

We will welcome the opportunity to assist you in evaluating "Delrin" for your own product designs. A letter or the coupon at right will bring a prompt reply.



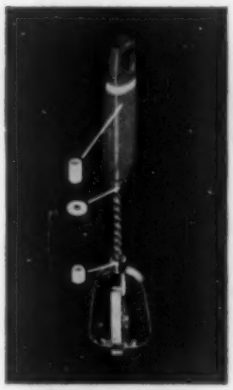
A ring of "Delrin" replaces nine steel balls in the bearings for roller conveyors produced by the Rapids-Standard Co., Inc., Grand Rapids, Mich. These new bearings offer the advantage of quiet operation. Beyond initial lubrication, no further lubrication is required. "Delrin" was specified because of its low coefficient of friction, high strength, corrosion resistance and dimensional stability. Bearings of "Delrin" are also featured in Rapistan® wheel conveyors. (Molded by Sinko Mfg. and Tool Co., Chicago.)

THIS IS WHAT DELRIN® IS DOING

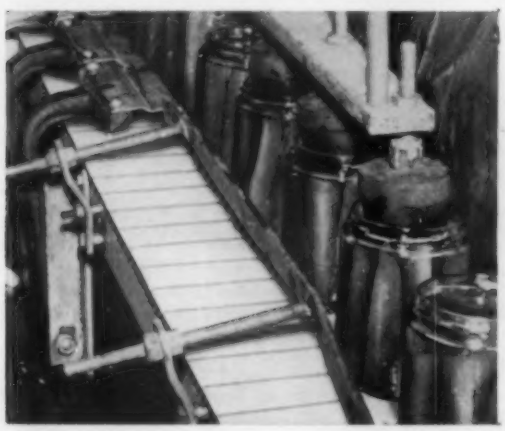
Now that "Delrin" acetal resin is available commercially, a rapidly increasing number of applications are going into commercial production: gears, bearings, housings, valve parts, plumbing fixtures, sporting equipment, telephone components, household items, clothing fitments, and many others.

During the past three years, over 500 applications of "Delrin" were field-tested by some 250 manufacturing concerns. The success of these wide-ranging tests suggests that "Delrin" may well help you, too, improve a product, lower its costs, or develop new designs for your profit. Commercial processors, and our own staff of technologists will gladly provide you with more information.

This one-hand egg beater features three parts of "Delrin" that replace a stamped brass bearing, a cold-rolled steel retainer and a brass bushing. The excellent frictional qualities of "Delrin" provide smoother, quieter operation. Tough and abrasion-resistant, "Delrin" provides a life span ten times longer than originally anticipated according to the manufacturer, Ekco Products Company, Chicago, Ill. (Molded by Vulcanized Rubber and Plastics Co., Morrisville, Pa.)



Flat-top conveyor chains of "Delrin" made by Fenco, Inc., Chicago, weigh only one-third as much as steel chains. Their service life is estimated at two to four times that of metal conveyors. Initial cost is 40-50% lower and little maintenance is required. The flat links of "Delrin" are strong, resistant to abrasion and corrosion, have a low coefficient of friction, require no lubrication. (Molded by Du Bois Plastics Product Company, Buffalo, N. Y.)



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Nemours Building, Wilmington 98, Delaware

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_____

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COMPANY_____ POSITION_____

STREET_____

CITY_____ STATE_____

In Canada: Du Pont of Canada Ltd., P. O. Box 660, Montreal, Que.

continued from page 17

Nearly 70% of the companies participating in the survey reported "a significant share" of the plant and equipment being installed this year will be accounted for by facilities to produce new products. The need for such facilities is especially acute in food, pulp and paper, chemical and auto industries.

The survey also indicates that a growing amount of corporate money is being budgeted for construction of R & D facilities. Industry as a whole will spend $682 million on labs; last year it spent 523 million. Of the money allocated to building labs this year, about one-fourth shows up in the metalworking industries.

BRITISH REPORT R & D GAINS

LONDON—British manufacturing industries spent $840 million on R & D in 1958, according to a report by the government-backed Dept of Scientific and Industrial research. Nearly 70% of this work took place in aircraft, electrical engineering and chemicals.

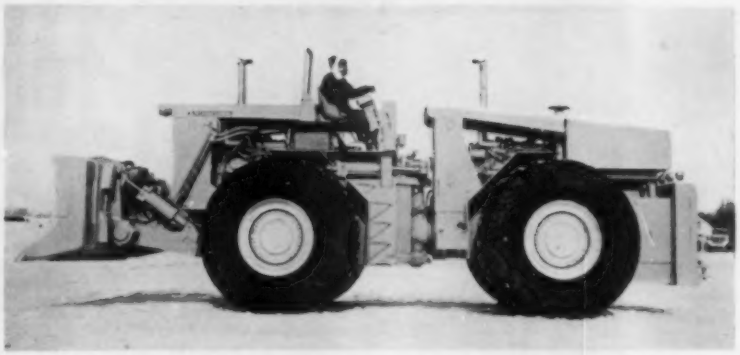
By US standards, the level is undoubtedly modest. But it shows a gain from the $532-million level shown in an earlier report for 1955. The 1958 R & D spending represented 4.2% of manufacturing's contribution to national production, compared with 3.1% in 1955.

Spending by the three industries in the land was: aircraft, $280 million; electrical engineering, $179.2 million; and chemicals, $120.4 million. Most of the R & D by British firms was done in their own labs. ■

Planned 1960 Expenditures for New R & D Facilities

Industry	(Millions of $)
Iron & steel	33
Nonferrous metals	7
Machinery	66
Electrical machinery	92
Autos, trucks & parts	53
Transportation equipment	94
Other metalworking	63
Chemicals	119
Paper & pulp	24
Rubber	5
Stone, clay & glass	30
Petroleum refining	28
Food & beverages	29
Textiles	11
Miscellaneous Manufacturing	28
ALL MANUFACTURING	682

Back-to-back Diesels Make Experimental Mammoth



International Harvester's Construction Equipment Engineering Dept designed this 75-ton, twin-engine earthmover as a combination front-end scraper and rear-end pusher (PE—Mar 21, p 20). Two 375-hp diesel engines give a top speed of better than 21 mph, and frame-steering permits turning inside a 24-ft radius. Axles are rigidly mounted to side frame-members—double-acting hydraulic cylinders on either side of vehicle push in opposite directions to jacknife the rig. Seat, steering wheel, accelerators and brakes are mounted on a turret that turns on roller bearings. To change direction, operator kicks a release and spins the turret around. Tripped by turning turret, a switch reverses oil flow in the steering system so vehicle steers the same forward or backward. (In picture, operator is facing backwards). Transmissions are single-stage, torque-converter-driven, power-shift systems giving 4 speeds in either direction. Unit is well balanced between its axles—about 77,415 lb on the front and 70,200 lb on the rear—and can push or pull about 90,000 lb.

California Passes Anti-smog Bill, Control Poses Problems

SACRAMENTO—California becomes the first state in the nation to require installation of devices on vehicles to control exhaust emissions (*PE—Feb 1, p 15*) but enforcement of the legislation looks to be several years away. The bill, backed by Gov Edmund G. Brown does this:

- Sets up a 13-member motor-vehicle pollution-control board with authority to test, and certify as satisfactory, exhaust control devices.
- Requires that the suppressors be on all gasoline-burning cars sold in California 12 months after at least two anti-smog devices are certified by the board as effective. Diesel-burning vehicles are exempt until the state establishes standards for emission.
- Requires the devices on all used cars, transferred in ownership, within one year; on all commercial vehicles within two years; and on all used vehicles within three years after selection of the official anti-smog devices.

One loophole in the bill allows any of the state's 58 counties to decide for itself that it's a non-smog area, relieving owners of the necessity of installing a device on present cars. However, new cars must be so equipped.

Enforcement and control look like other trouble areas. The fitting of a device on a car does not guarantee miles or years of trouble-free service. And what about cars going from a non-smog to a smog area?

The original bill provided for a state testing laboratory; however, the final bill amended this portion after a successful argument by Dr C. E. P. Jeffreys, technical director of Truesdail Laboratories and representing the American Council of Independent Laboratories, Western Div. "There are nearly 600 highly trained scientists workers in the 15 independent member laboratories, and their work has brought forth much of the knowledge we have today about air pollution in the state," he told the Senate Transportation Committee when the bill was considered. "We have the instrumentation and are organized to meet the keen competition existing in our field. If additional research is needed on refinements of exhaust-gas analysis, the state should contact those familiar with the problem and not set up duplicate facilities."

Approved devices will have to meet the already adopted formula for emissions. It decrees that no emissions

greater than 275 parts per million of hydro-carbons and ½ to 1% (by volume) of carbon monoxide will be permitted.

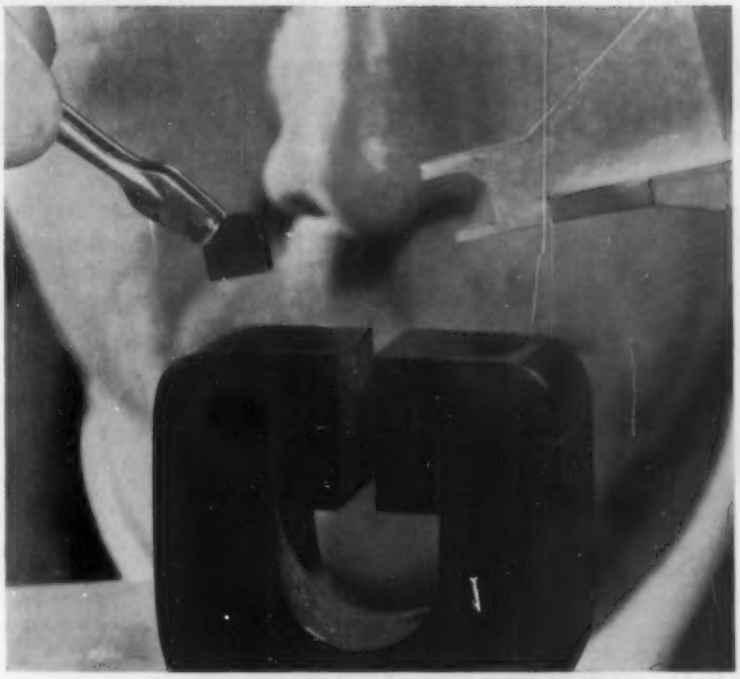
While most observers don't expect anti-smog devices to be installed before 1962, Assemblyman Ronald Cameron, who authored the bill, is more optimistic. He believes it will not take the board more than 12 months to select effective anti-smog devices, and that they will be on 1962 model cars. He points out that "there are at least a dozen devices that meet the requirements."

MORE SMOG STUDIES

PHILADELPHIA—This Pennsylvania city has joined the ranks of municipalities studying the effects of automobile and truck exhaust on air pollution. Last week the Philadelphia Air Pollution Control Board named a chairman to head a special committee that will investigate the contribution of motor vehicle exhaust to the smog that occurs in the area from time to time. Though smog is not a major problem here at present, the board feels investigation is needed.

Board chairman L. Arnold Nicholson credits about 50% of the smog-producing gases in the city's atmosphere to cars and trucks. ■

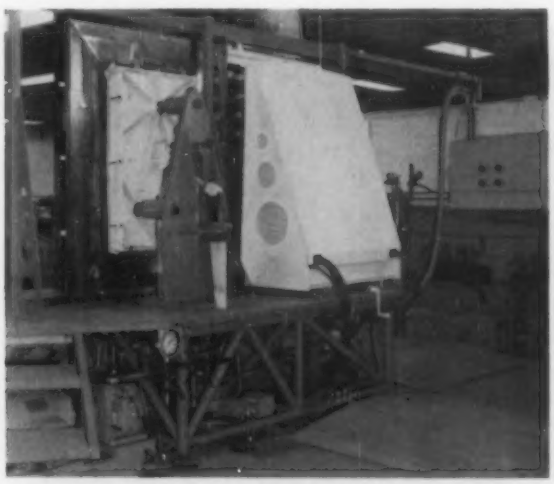
Lending a sensitive ear



Magnet in foreground, together with half-inch-square crystal of synthetic ruby and copper transition section, form the "ruby maser" amplifier developed by Hughes Aircraft Co for the US Signal Corp. The 25-lb maser (Microwave Amplification by Simulated Emission of Radiation) is sensitive enough to detect and amplify even extremely weak signals from stars or space vehicles millions of miles away. A conventional maser uses a 500-lb magnet and costs $4000; magnet in the Hughes-built device weighs 12 oz, costs $10.

Radiant Quartz Lamps Speed Brazing

Steel honeycomb, which has been successfully formed into small curved and wedge-shaped panels will now be turned out in a wide variety of sizes and shapes. This development is result of a contract between Northrop Corp and the Manufacturing Methods Div of Wright-Patterson Air Force Base. Air Force wants to use the panels in advanced aircraft and space vehicles. Honeycomb panel is brazed between banks of electronically controlled radiant quartz

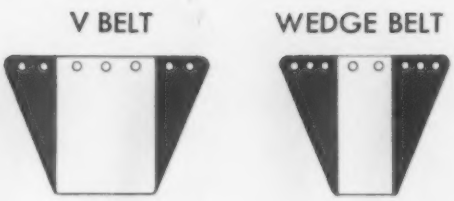


lamps (left). Lamps provide heat to 6000 F. At right, is stainless steel panel in its airtight envelope being held in the chill position. Part has just moved from between banks of radiant brazing lamps, to right of chill position. Carriage frame supporting the enveloped part is covered with gold-fired shields—their high reflectivity prevents overheating the structure surrounding brazed area during brazing cycle.

An important Worthington message about

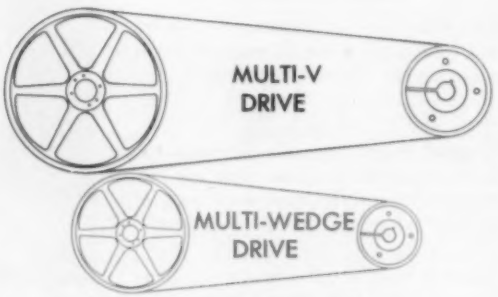
THE COMING CHANGEOVER FROM

Recently you may have seen a number of announcements promising "super" V-belt drives that are considerably smaller and less expensive. What these manufacturers are talking about, of course, is the new Wedge belt which will soon replace conventional V belts for new belt



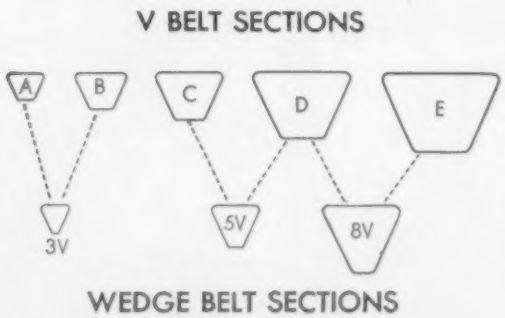
Q. What is a Wedge belt?

A. The cord layer near the top of a V belt carries the load. This layer, however, is only efficient in the portion supported by side walls (red areas). Because it is more of a pie shape, a Wedge belt increases the overall efficiency of a V belt. The Goodyear Tire and Rubber Company (manufacturer of Worthington-Goodyear V belts) was the first to offer a Wedge belt (in 1948). This fine product, however, was sold primarily for automotive applications.



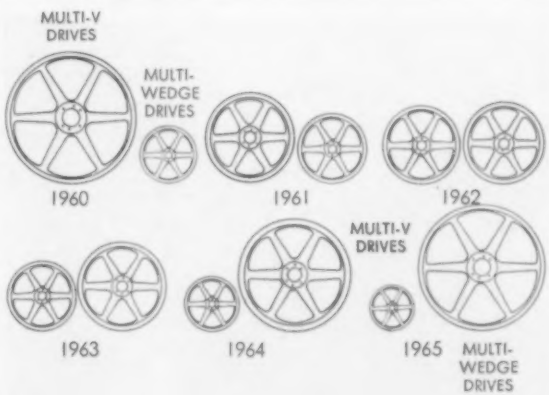
Q. What are the advantages of Wedge belts?

A. Smaller size, lower cost. Because the new Wedge belts are more efficient, you need fewer belts and smaller sheaves to carry the same horsepower load. Sheave diameters can be reduced 30 to 50%. Center distances can be cut 20%. And initial cost can be as much as 20% less.



Q. What belt sizes will be available?

A. Since the smaller Wedge belt does more work than the other V belt, it has been possible to reduce the number of sizes without loss of flexibility. The new Wedge belts will be available in three standard sections, 3V, 5V and 8V. The new nomenclature simplifies identification. The 3V belt is three eighths of an inch in width (measured at the top); the 5V belt is five eighths; the 8V belt, eight eighths, or one inch. Stock 3V and 5V sheaves will cover horsepower ranges up through 200 hp. Made to order 8V sheaves will be used for 200 to 2,000 hp. requirements.



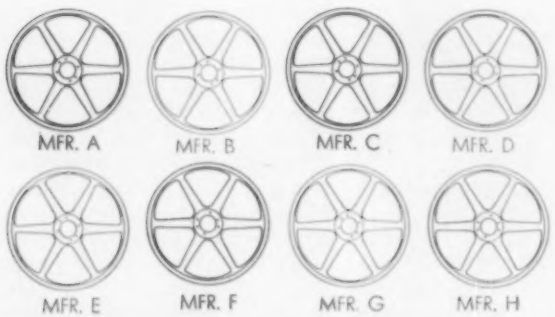
Q. Will multi-V drives continue to be available?

A. Worthington has no intention forcing any customer to switch to the new Multi-Wedge drive. The choice is up to you. We will continue to manufacture and stock both drives as long as there is a demand for both. We expect that many customers will need replacement belts and sheaves for Multi-V drives for many years. The chart above indicates how we expect the market to be divided in the years ahead.

MULTI-V TO MULTI-WEDGE DRIVE

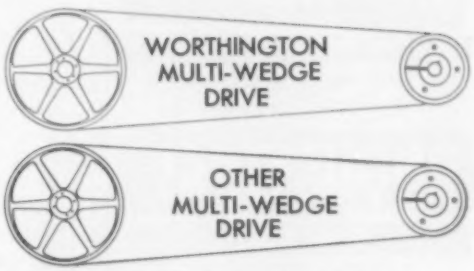
drive applications. On these pages Worthington—maker of the QD (Quick Detachable) sheave, the industry's largest seller—explains the significance of the coming change-over. If you would like more information please write to Worthington Corp., Section 79-25, Oil City, Pa.

WORTHINGTON



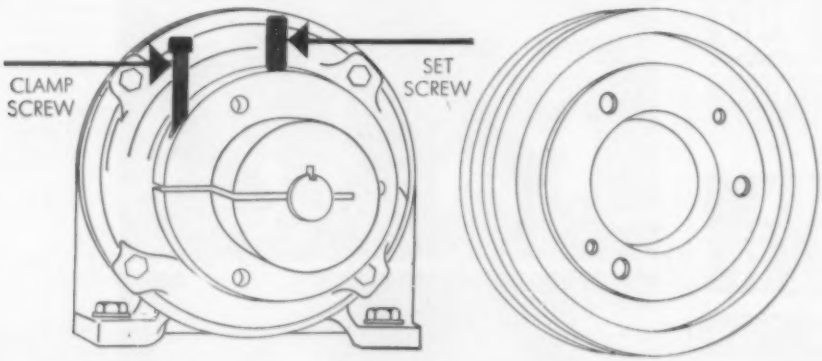
Q. Will all drive manufacturers make the changeover?

A. All indications are that the majority of Multi-V drive manufacturers are going to switch to the new Wedge belts. Of the eight leading builders, five (including Worthington) now also offer Multi-Wedge drives.



Q. Will different brands be interchangeable?

A. So far all Multi-Wedge drives introduced are being offered in the same belt and sheave sizes. Since Worthington and its QD licensees enjoy the largest share of the market, you can be doubly sure of having a dependable source of supply if you buy your Multi-Wedge drives from Worthington. All stock QD sheaves are being built to standardized dimensions by all QD manufacturers and are therefore interchangeable.



Q. Are all Multi-Wedge drives alike?

A. Whether you buy a new Multi-Wedge drive or the older Multi-V drive, the major difference between brands will be the quality of the belt and the method of locking the hub to the shaft. Worthington QD (Quick Detachable) sheaves, with their two Golden Screws are preferred by plant operators because of their positive locking arrangement.

The clamp screw simplifies installation and assures permanent alignment. You can install QD sheaves one part at a time. No heavy rim and hub combination to inch delicately into place. If change in speed is required, you simply install another sheave on the hub which remains anchored to the shaft. The clamp screw is an exclusive Worthington feature.

The set screw prevents "key drift." It locks the key securely in place, avoiding the danger of the key drifting off and becoming a safety hazard. Because of the exclusive clamp screw it is possible to use a set screw without causing hub distortion that might cause eccentric runout.

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THE ENGINEERING WEEK

Japanese Manufacturers Emphasize Consumer Products

OSAKA, JAPAN—A boom in consumer goods, which has been spurring Japanese industry recently, was sharply evident here at the annual Japanese Industrial Trade Fair. A vast array of new products and new designs by new companies was on display. These products were designed for export to the relatively high standard-of-living countries in the West as well as for domestic and Asiatic consumption.

Electronic goods for consumers dominated the show. Virtually every manufacturer showed his own version of stereo phonograph equipment. Standard Radio Corp, which markets in the US through Dumont-Emerson, showed a combination radio-phonograph said to be the smallest in the world. Color TV sets were also numerous.

Many of the smaller companies showed transistor radios, interoffice communication systems, tape recorders and battery-operated transistor-type portable phonographs. One tape recorder was no larger than a 35mm camera.

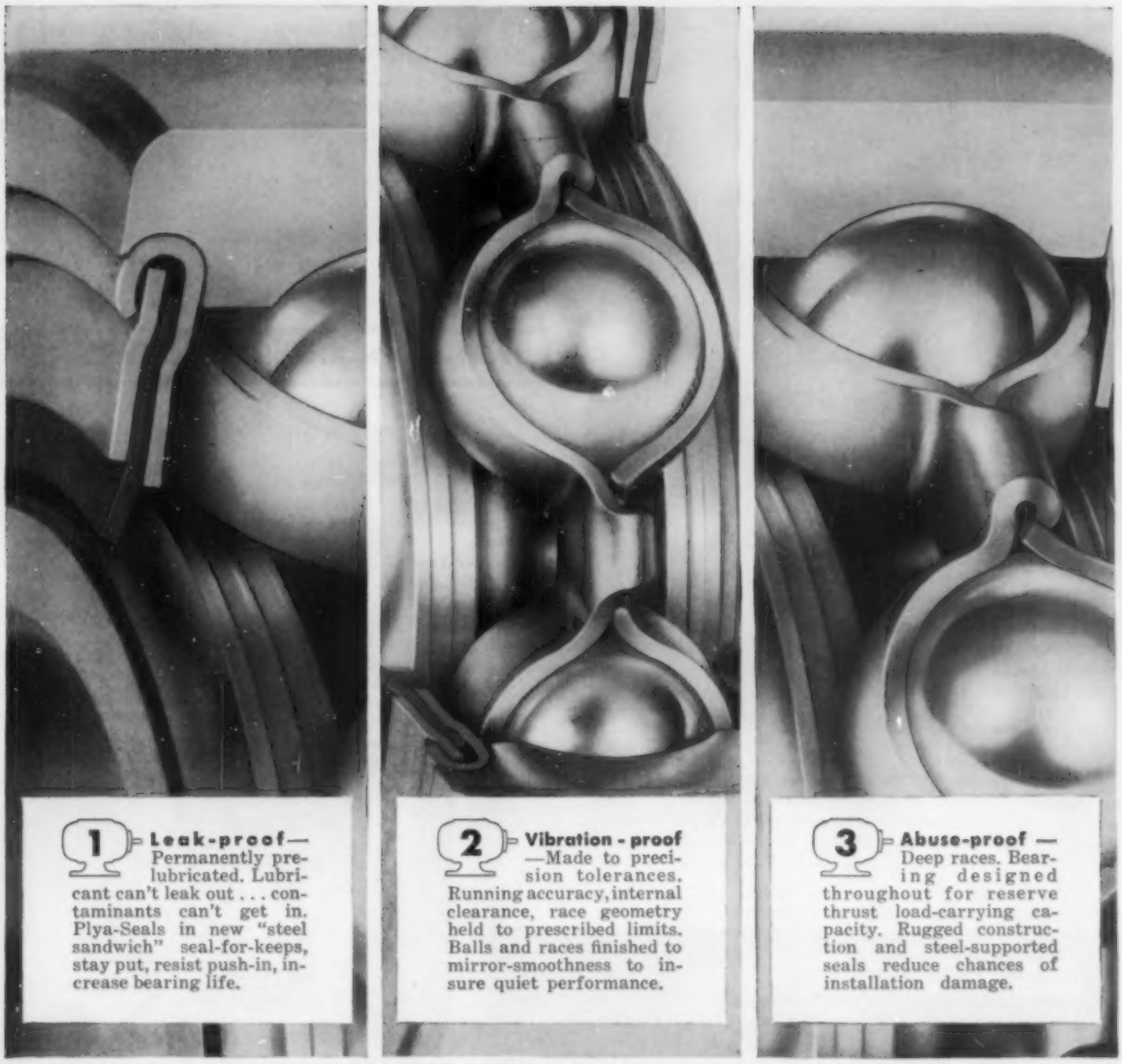
Japanese appliance dealers at the Fair are showing increased facility in designing refrigerators, washers and other appliances especially for Japanese homes. In the past, they have usually shown small versions of American appliances. Particularly evident in this category were the square, flat-top refrigerators styled for the tiny Japanese kitchens.

Mitsubishi Heavy Industries Ltd was on hand with its new Mitsubishi 500. This two-seat vehicle is the company's candidate for a "people's auto." Both Mitsubishi and Kubota showed small tillers—an agricultural equipment design that, when mass-produced, is expected to help solve the food problems in India, Pakistan and other densely populated Asian countries.

Included in displays of industrial equipment were machine tools controlled by digital computers. And Yaskawa Electric Industries showed a model of a computer with "parametrons"—a Japanese-developed semiconductor not yet taken up by the West. —Sol Sanders, Tokyo Bureau

AUTOS and accessories took up one entire Fair building. Shown, center foreground, is Mitsubishi's 500 — a car for the Japanese market that will sell for about $1000. Behind the 500 is Toyota's new Corona — designed for the US market.

THIS TILLER, designed by Kubota, is credited with helping to raise Japanese agricultural productivity enough to make the country self-sufficient in rice. Kubota and other companies are now aiming to market in other Asian countries.



1 **Leak-proof**—Permanently pre-lubricated. Lubricant can't leak out . . . contaminants can't get in. Plya-Seals in new "steel sandwich" seal-for-keeps, stay put, resist push-in, increase bearing life.

2 **Vibration - proof**—Made to precision tolerances. Running accuracy, internal clearance, race geometry held to prescribed limits. Balls and races finished to mirror-smoothness to insure quiet performance.

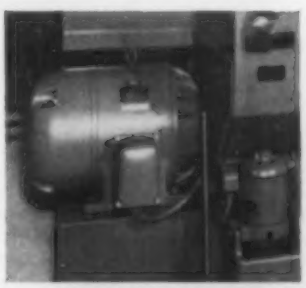
3 **Abuse-proof**—Deep races. Bearing designed throughout for reserve thrust load-carrying capacity. Rugged construction and steel-supported seals reduce chances of installation damage.

Fafnir gives you the seal . . . the "smoothness" . . . the stamina you need in ball bearings for electric motors!

Notice the seals in this Fafnir ball bearing. They're "rolled in". These newly designed Plya-Seals won't work loose because they are gripped between two steel supports . . . nor will they push in. They provide positive protection against contaminants and loss of lubricant.

You also get whisper-quiet performance. Balls and races in Fafnir precision ball bearings for electric motors are micro-finished to mirror-smoothness. No noise . . . no vibration. Extra-deep race design adds thrust capacity and minimizes mounting damage.

Look to Fafnir for *your* electric motor ball bearings. You'll find all sizes and types (open, shielded, or with contact, slinger, or felt type seals) . . . plus the capacity and uniformly high quality to meet your needs precisely. The Fafnir Bearing Company, New Britain, Conn.



Over 5000 electric motors in Fafnir's six plants including these 10 HP and ½ HP units, offer on-the-spot proving-grounds for electric motor bearing designs.

FAFNIR
BALL BEARINGS

TRENDS IN APPEARANCE DESIGN

THE DESK-CONSOLE at left (closeup below left) represents a radical departure from the former 19-in. rack version of this testing equipment for airborne computers. Besides achieving greater component density and reducing space required, redesigned panel is easier to read, eliminates parallax and also makes possible presentation of more symbols. Also, in former model, patchboard containing testing program had to be plugged into socket awkwardly located half underneath top panel. Now it's inserted beneath socket's dust cover at right of console.

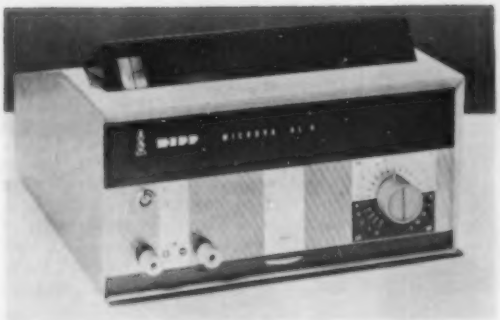
■ Instruments for testing airborne computers made by Servomechanisms Inc evolved within the standard 19-in. rack typical of such electronic equipment. This "add-on" approach contributed to the jumbled "electronic look" (top of page) of electronic labs. Although the 19-in. rack itself was a modular concept, the need for greater flexibility and accessibility is causing the redesign of several types of such instrumentation.

One example of this trend, the new testing system for airborne computers now being developed and marketed by Servomechanisms, includes a desk, a cabinet and consoles that can be fitted on top of either, permitting a variety of combinations for different applications. Along with the better appearance and the provision for human factors affecting their design, this new series of instruments also achieves greater component density—and in less space, both volumetrically and in terms of required floor area. Another change from design practice connected with the old 19-in. racks is the specification of Formica desk and cabinet tops in place of enameled finishes, and the use of extruded aluminum structural shapes. Industrial design consultants: Zierhut, Vedder, Shimano, Van Nuys, Calif. ■

1

2

. . . INSTRUMENTS



3

4

5

1 TRANSPARENT POLYSTYRENE DIAL cover is integral part of functionally minimum case of voltage- and current-measuring instrument for electronic equipment. Yet it has drawbacks, as indicated by distorting effect on some of figures around adjustment knob in lower right-hand corner. Also, display of measuring ranges (there are supposed to be 31) is confusing. Made by N V Instrumenten-on Electrische Apparatenfabrik NIEAF, Holland.

2 TAPE-CONTROLLED TESTING SYSTEM for checking out electronic products, receiving inspection. Even such large equipment as aircraft electronic apparatus retains sliding-rack module for its variable-circuit components, yet achieves integrated appearance by recessing racks behind cabinet doors. By Pacific Automation Products Inc, Glendale, Calif.

3 MULTIPLE-RANGE MICROAMMETER eases readings by using light-spot galvanometer that projects settings on linear scale. Front control panel is uncluttered, but decorative treatment detracts from its simplicity. Made in Holland and distributed here by James G. Biddle Co, Philadelphia.

4 ANALYTICAL MASS spectrometer's cabinets are constructed of Formica-and-honeycomb panels, which are said to expose internal mechanisms more completely for servicing. Also, each electronic chassis tips rather than slides out, eliminating the classic sliding drawer. By Analytical and Control Div, Consolidated Electrodynamics Corp, sub Bell & Howell Co, Pasadena, Calif.

5 VACUUM-TUBE VOLTMETER is sold as a do-it-yourself kit, to be constructed by customer's own technicians. Absence of knobs and other such hand controls on front panel results from incorporation of an automatic range selector. Designed by Latham-Tyler-Jenson, Chicago, for Allied Radio Corp.

6 AUTOMATIC FOCUSING MICROSCOPE uses prominent scoring of adjusting controls to aid identification by both sight and touch. Unusual frame design helps to keep center of gravity on optical axis, no matter how heavy the accessories (note television camera at right) mounted on the instrument. Made in France and distributed by Precitec Co Inc, Andover, Mass.

6

DRAFTING TRENDS

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READER TO EDITOR

What's Really Behind The "Engineer Shortage"?

To the Editor:

Articles, such as "Technicians—Answer to the Shortage of Engineers" (Mar 14, p 55), which discuss the reasons for the "shortage" and ways of alleviating it, usually consider education, social motivation, and other applicable points. Invariably, this article, as in all such "shortage" articles, neglects a frank discussion of the well-known, universal motivation called money.

If the author would only dig out the facts about salaries—starting salaries as well as those after 5, 10, 20, and 30 years' experience—I am sure that we would all benefit, and many of the reasons for these perplexing shortages would be immediately obvious.

—ROBERT B KELLER
Ann Arbor, Mich

• The article on technicians was intended to suggest that many students who start in engineering schools should never do so. They'd be much better off in a technician training school of some kind. We're continually horrified by the fact that 55% of entering freshmen engineers never graduate.

Mr Keller says better salaries would solve the whole problem. This is pretty difficult to prove. Starting salaries of engineers in 1960 will be $515 per month—more than 10% higher than for all other college graduates ($457 per month). Figures on annual salaries of experienced engineers are $9250 at 10 years' experience, and $11,200 after 20 years. Lawyers, in 1959, averaged $12,000 after 20 year's experience.

Physicians have always been the highest paid—but this is partly because of their advanced degree. The average income for physicians is $15,000. Engineers with doctor's degrees are within 10% of this figure. Despite the obvious attraction the medical profession should have, *US News and World Report* (Nov 9, 1959) predicts a shortage of physicians. There are fewer physicians now available than there were 10 years ago and the situation is certain to get worse. —RMK

Engineers and Draftsmen

To the Editor:

The discussion of the draftsman's work and his relation to the engineer in "Points of View" published in the Dec 14 issue was timely and interesting. It seems to me that the proper status and functions of the draftsman are not adequately described by some of the comments. Let us see how the prevalent deprecatory view might have come about. Forty years ago many draftsmen graduated to the drafting office from the shop. Many had been machinists, toolmakers and diemakers and had the "feel" for what they were dealing with. During World War II many draftsmen were converted "shoe clerks." Young men were pulled in off

the street and taught detailing. Since they lacked practical, first-hand experience, their judgment in matters of fits and limits, stresses, materials and manufacturability was pitifully meager. They, therefore, became merely experts in the making of pictures.

There is, however, a developing trend at present. Draftsmen are taking more interest in the functioning of the product. They are preparing themselves more thoroughly both on the job and in off hours. The work of the engineer, on the other hand, is coming to be considered as the adaptation of basic science of a specific technology. He is seen as an "engineer-scientist." It is my feeling that in our modern setup the proper role of the engineer is to be a researcher and developer of basic technology. He cannot, as such, spare the time for the more routine details of design. It is rather unfair to visualize the draftsman as a mere translator or interpreter simply because he must be an expert in the use of the language of engineering and drafting. The draftsman is needed to take up where the engineer must leave off, and to exercise his talents towards "making the design work."

Unless the progressive draftsman we all would like to hire can find a challenge in his work somewhat commensurate with his preparation and experience, he will hop from job to job until he finds it. There is scarcely a greater injustice or waste than that of freezing a man's opportunity to use his capabilities to a satisfying extent. We are dealing here not merely with functions to be performed but with lives to be lived.

Part of the problem is to recognize what an engineer should be. It has been observed many times that the shortage of engineers is not actual but induced by the fact that in numerous cases engineering graduates are kept busy with details, paper work and various extraneous duties. The highly trained and indisputably competent men in the field of drafting and design might better be bearing their share of the burden as well as an appropriate title, thus releasing the engineer to his proper calling. In my experience I have seen many fine examples of tool, machine and product design executed by men without engineering degrees. The line of demarcation between the draftsman-designer and the experienced engineering graduate is not sharp.

If the engineer operates within his proper sphere he has no need to be concerned about the draftsman encroaching upon his jealously guarded bailiwick. Rather, the draftsman-designer can be of great assistance to the engineer in relieving him of many practical details. The "draftsman" should not, let us hope, be compressed into the role of a mere translator or interpreter of designs in which he may not participate.

Regarding a universal drafting and engineering language, note the following: In November 1950, military and industrial representatives of the US, Great Britain, and Canada held a conference for the unification of engineering drawing practices and preliminary agreements were

continued on page 30

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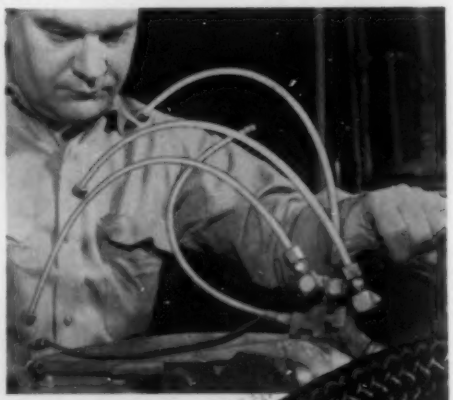

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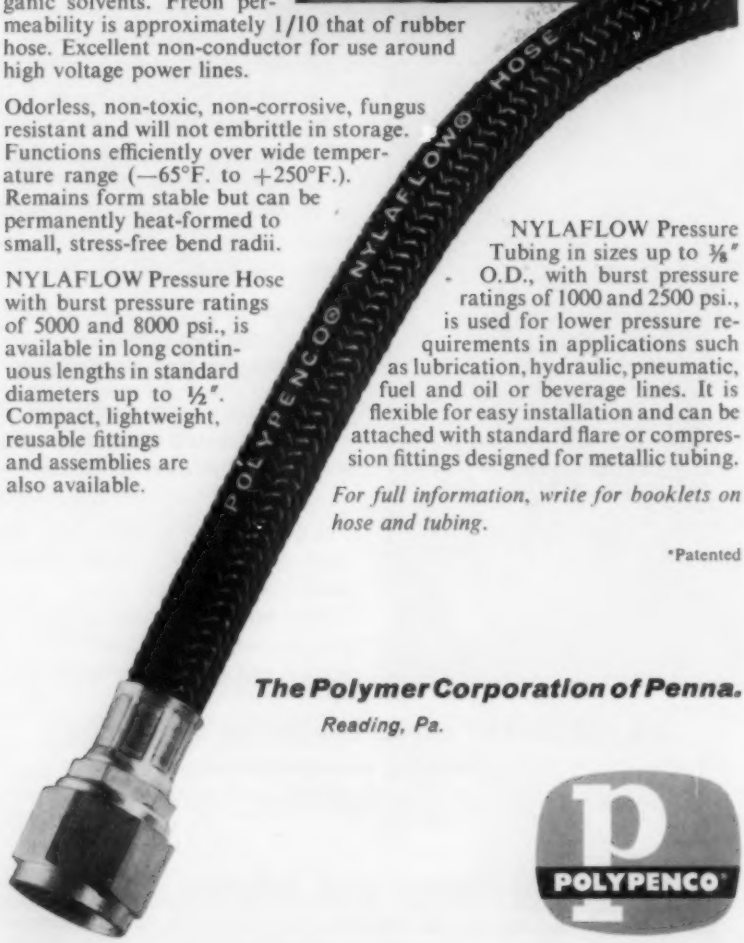

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reached. At a subsequent ABC conference (June 1952), there was general agreement that an adequate universal system of drafting symbols should be developed. Some of the recommendations were later incorporated in the MIL-STD-8, the military standard for dimensioning and tolerancing. The delegates to the October 1957 ABC conference at Toronto, Canada considered and made recommendations for format of drawings, projection, line conventions, sections, screw-thread representation and tolerances of position and form. The past ten years of conference work toward unification has been eminently productive. The trend toward uniformity of practice among segments of industry is also quite definitely active. Certainly, we can look forward to that universal engineering drafting language so devoutly desired.

Mr Smith has mentioned his experience with an example of a version of a drafting communications link that was effective only locally—that is, among draftsmen. He is right in feeling that a drafting language should be understood by all those who must use the drawings—the engineer, the draftsman, the manufacturer, the inspector, etc. The solution, however, is not to have everything written out in long-hand. It is as necessary and appropriate to apply symbolism on drawings as anywhere else. I agree that various agencies should participate in the development of a universal communication system for engineering designs. And that is precisely what is happening. The delegates to the ABC Conferences on the Unification of Engineering Drawing Practices are engineers, drafting experts, representatives of manufacturing, and military men.

Once a well-founded and workable system is developed, however, it has to be adopted generally to be effective. Admittedly, it is going to be difficult to persuade some to lay aside the procedures they have considered adequate for years and to make the effort to study and adjust to something different, effective as it may be.

—Arthur Russell
Albuquerque, NM

Aircooled Engines for Smog Control

To the Editor:

I wanted for some time to comment on your very interesting article, "Can We Design Out Smog?" Feb 1, p 15. Present-day cars are already overstuffed with various gadgets, and it would not be wise to make them more complicated, thus requiring more frequent service. (Especially the compact cars.)

It is clear that something has to be done to combat smog, not only in the Los Angeles area but in all large cities. I read with interest the report of recent tests made by Chrysler for better car maintenance, which resulted in finding better combustion efficiency and reducing hydrocarbons in exhaust by 50%. The idea to vent the crankcase fumes back into the engine, to be burned there, is very

good and should be fully accepted.

If more car manufacturers would change to aircooled engines like those in the Volkswagen and Chevrolet's Corvair, the picture would be quite different. Exhaust gases are usually 900 to 1300 F. At such temperatures most hydrocarbons would burn directly in the aircooled combustion chamber and there would be no need for an expensive afterburner. Furthermore, as the Germans already have recognized, aircooled engines will last almost twice as long as watercooled ones. And last, but not least, there will be no more trouble with corroded mufflers, because all the corrosion-causing acids will be burned right during the combustion cycle in hot cylinders.

The only disadvantage of an aircooled engine, so far as I know, is the noise—it has no watercooled jacket to act as a sound insulator. Perhaps some ambitious engineer can make aircooled engines quiet also.

Cars can be made cheaper when no radiators, water pumps or cooling jackets are needed. The inner oil-cooling of pistons, should be accepted fully in case aircooled engines are adopted.

—Otto V Drtina
Chief Design Engineer
Nylonge Corp, Cleveland

COMING EVENTS

MAY

8-11 . . . . National Fluid Power Association, 1960 Spring Meeting, Grand Hotel, Point Clear, Ala

9-13 . . . . Society of Photographic Scientists and Engineers, 1960 Annual Conference, Miramar Hotel, Los Angeles

9-13 . . . American Society for Metals, Southwestern Metal Show, State Fair Park, Dallas

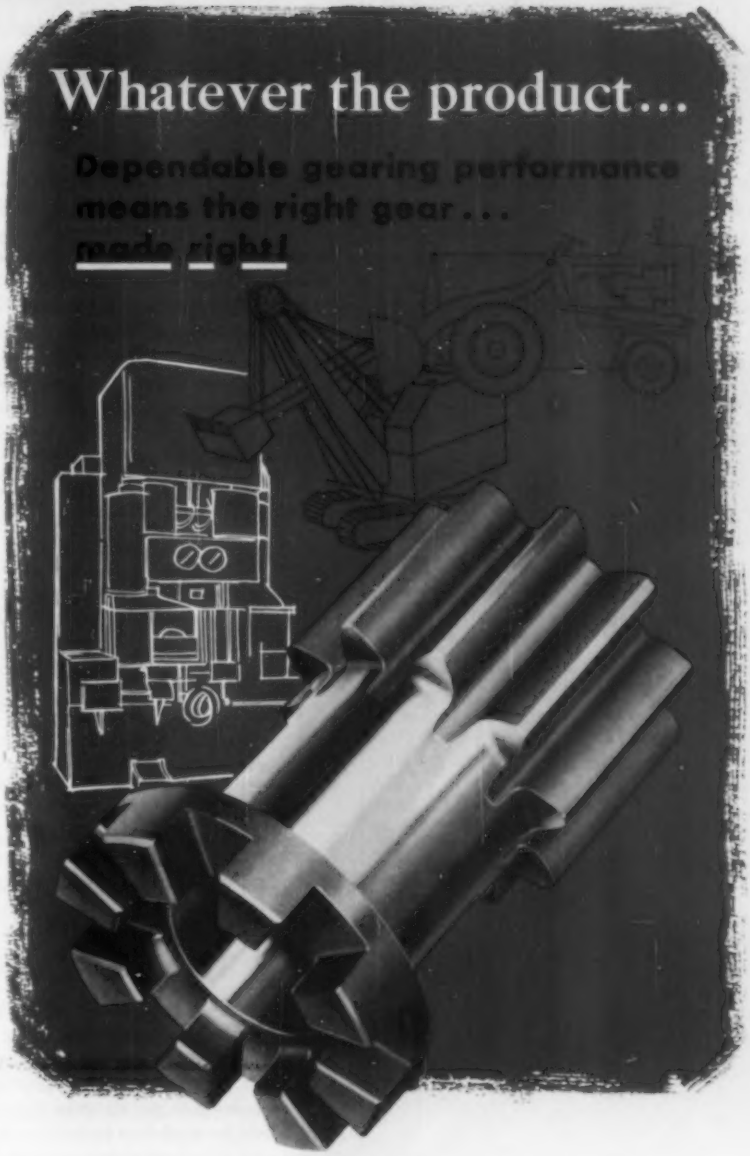
10-12 . . . . American Institute of Electrical Engineers, Institute of Radio Engineers, Electronic Industries Assn, Western Electronic Manufacturers Assn–Electronic Components Conference, Washington, DC

18-20 . . . . Society for Experimental Stress Analysis, Stress Analysis in Propulsion Systems, Indianapolis

23-26 . . . . American Society of Mechanical Engineers, Design Engineering Conference, New York Coliseum, NYC

23-26 . . . . Clapp & Poliak, Design Engineering Show, New York Coliseum, NYC

23-26 . . . . American Institute of Electrical Engineers, Instrument Society of America, American Rocket Society, Institute of Aeronautical Sciences–National Telemetering Conference, Marimar Hotel, Santa Monica, Calif.



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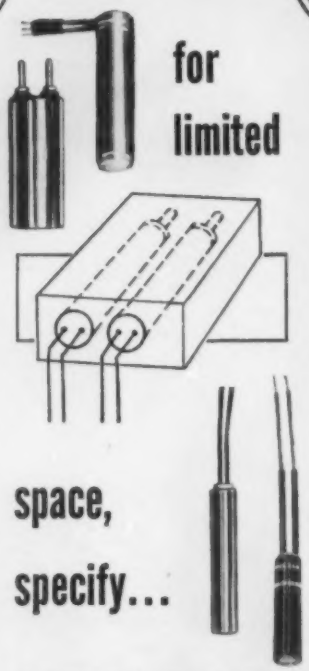

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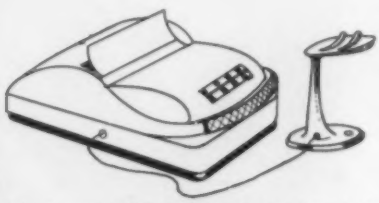
WHY DON'T THEY R&D..?

Inspired by the vast implications of the Space Age and all it promises, the engineers of Royal McBee's Research and Development department (Industrial Design Section) have allowed their thoughts to spin off into orbits where "nothing is impossible; it's only a matter of how long it will take to perfect it" —or, at least, that's the way their internal magazine *Royal News* puts it. Most compelling problem, according to them, is the matter of communication—coding, transmission, storage and retrieval of information. Fearlessly tossing caution to the winds, Royal McBee engineers foresee the time when "we can transmit our thoughts on wavelengths similar to microwaves and, through a viewer similar to a television screen, actually see our thoughts in picture form." To give us an idea of what they are talking about, the engineers have served up some of their "thoughts in picture form" (below). Some look rather "blue sky" at the moment, others seem quite practical. But in either case, there are undoubtedly germs for a number of new products here. Any ideas?



Vocabulator—a voice-activated typewriter. Microphone converts spoken words into electronic signals to actuate appropriate keys of a typewriter. Chief problem is recognizing the distinguishing sounds of each word, regardless of individual variations in tone of voice or accent. Most successful technique to date is to match input signals with computer-stored signals and thus generate appropriate signals for keys of typewriter. RCA built one that had a vocabulary of about 10 words. But the words were chosen because of their distinctly different sounds and the equipment filled five or six standard electronic racks. Secondary problem: what to do with such word pairs as "weight" and "wait," "write" and "right," "raise" and "rays," etc.

Rotograph—a high-speed manual typewriter. Machine combines flying wheel line-printer commonly used for computer printout with photoelectric keys such as the touch-sensitive, elevator call-buttons now found in modern buildings. Because keys can be operated without pressure, it is likely that some other arrangement of keyboard would give more speed. A vertical board, a contoured board, or board mounted to accommodate the most relaxed position of the hands, might be found more comfortable than present sloping keyboards. Sketch shows a vertical keyboard divided in two segments.

Ceremax—a thought-transmitting center. A device worn on the head transmits brain impulses to a "thought scriber" where they are recorded in pictorial form for monitoring or rebroadcast via television. This sounds a bit farfetched, but Russians report that they have a device that moves a mechanical arm in response to nerve signals tapped from the arm of an operator. Other developments in the field of bioelectronics (*PE*—Nov 30 '59, p 9) promise that mechanisms controlled by brain impulses may be common in the near future.

Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.

CIRCLE 32 ON READER SERVICE CARD

CIRCLE 33 ON READER SERVICE CARD→

THESE NEW B-L-H GAGES

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Since its initial development, some 20 years ago, the SR-4 Bonded Filament Strain Gage has simplified the approach to countless structural analysis and design problems, many of which would otherwise have been immensely difficult, if not impossible, to solve accurately.

Through the years literally hundreds of SR-4 gage types and configurations have been produced, each designed to solve a particular strain measurement problem as easily and precisely as possible.

Now, four new additions to the B-L-H strain gage family make possible still greater simplification of a variety of stress analysis jobs. One of them may be the answer to your problem.

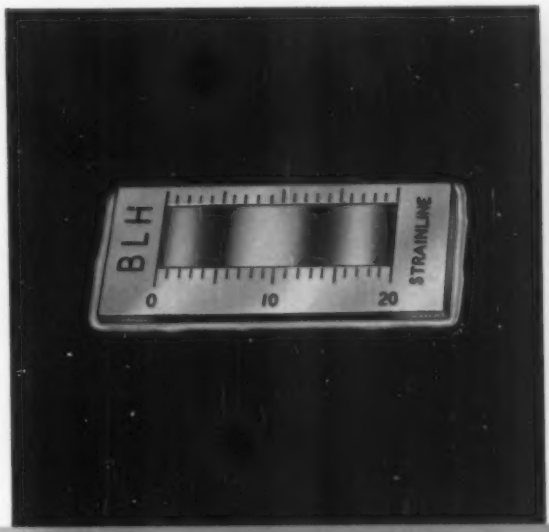
STRAINLINE PHOTOELASTIC STRAIN GAGE

For the researcher or engineer who would like direct indication of strain, without resorting to electronic instrumentation, time-consuming connections, etc., the new Strainline photoelastic strain gage is an ideal solution.

Small, rugged, very simple to install and use, Strainline gages provide immediate, visual indication of strain magnitude. Each gage displays a series of visible transverse interference lines. When it is bonded to a surface undergoing strain, these lines are displaced along the length of the gage. The magnitude of displacement, with respect to a fixed scale on the gage mask, is directly proportional to the strain.

Unlike other photoelastic devices, the Strainline gage has negligible transverse sensitivity . . . no correction of readings is necessary. Its fringe lines are sharper and easier to read accurately (to better than 50 microinches per inch) in either natural or artificial light.

Strainline gages are available with gage lengths of ¾″ and 2″. For more information ask for Product Data 4325.



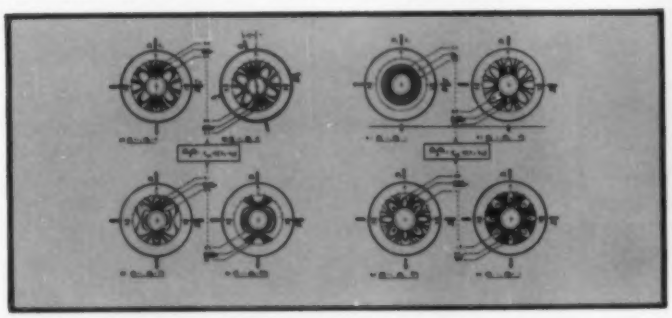
STRAINLINE PHOTOELASTIC STRAIN COMPASS

A natural companion to the Strainline gage is the Strainline compass. A truly unique photoelastic device, this small, circular gage provides quick visual indication of strain direction.

When a surface to which it is bonded undergoes strain, a symmetrical pattern of interference fringes appears on the face of the gage. The axes of symmetry of this pattern provide clear, immediate indication of the directions of principal strain.

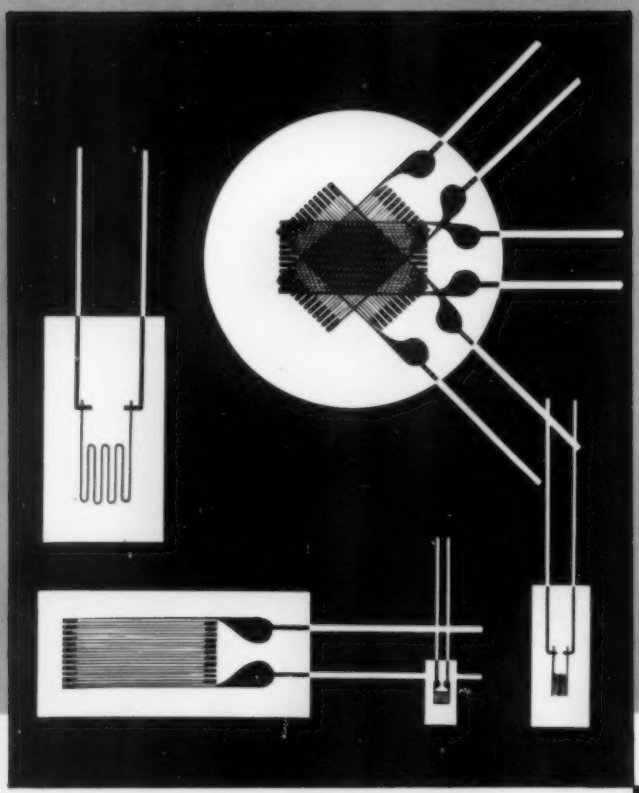
A number of Strainline compasses, bonded to a test area may be photographed or observed simultaneously to determine localized strain direction over the entire area at any given instant.

Strainline compasses are available with diameters of ⅜″ and 1″. For more information ask for Product Data 4326.



Theoretical shearing stress distribution for different stress ratios.

MORE NEW **SR-4**® STRAIN GAGES ON NEXT PAGE



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Probably the easiest way to compensate for temperature effects on strain gage readings is to use a gage which is "matched" to the material of the surface under test.

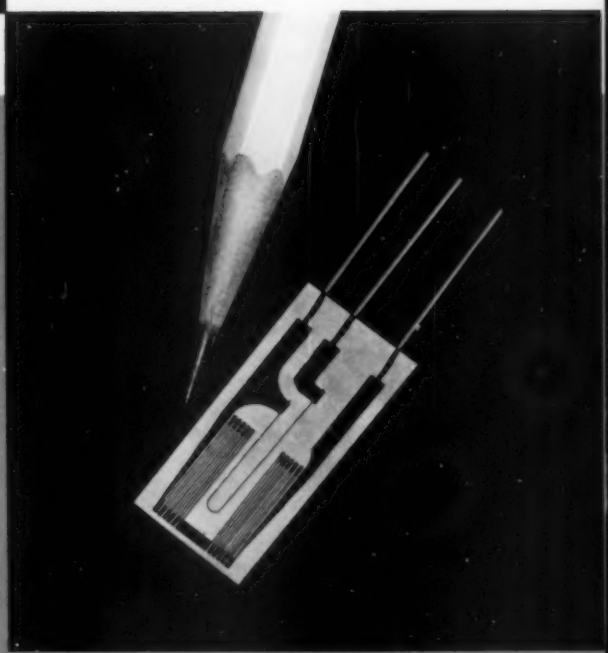
A new and complete line of these matched, or "Selected-Melt," gages of both wire and foil grid construction is now available from B-L-H for use on a variety of materials. Produced from alloy batches or "melts" which have been carefully selected to exhibit certain predetermined thermal coefficient of resistance characteristics, these gages produce apparent strains of no more than $\pm 1\ \mu''/''/°F$ over the range of from 50 to 250°F.

Most of the commonly-used SR-4® wire and foil strain gage types are now available with Selected-Melt grids. Three characteristic melts are offered for each gage type, making Selected-Melt strain gages applicable to materials having thermal expansion coefficients of 6 (e. g., mild steel), 9 (stainless), and 13 (aluminum) parts (± 1 part) per million per °F.

Melts are also available on special order for materials having other coefficients.

Ask your SR-4® Strain Gage representative how new "Selected-Melt" gages can fit into your testing problem.

For more information ask for Product Data 4313.



SR-4® UNIVERSALLY-TEMPERATURE-COMPENSATED STRAIN GAGES

Although it serves a useful and important function, each self-temperature-compensated strain gage is necessarily restricted in use to the specific material for which it is intended and over a limited temperature range.

The new universally-temperature-compensated gage, however, may be used with a high degree of accuracy on almost any material. In addition, it will provide compensation over an extremely wide temperature range.

The temperature response characteristics of this remarkable new gage can be changed by varying the parameters of a simple external circuit. Two models are available, each with a gage length of ½". Type FNB-50-12E, on a phenolic base, is recommended for use from −320°F to +500°F.

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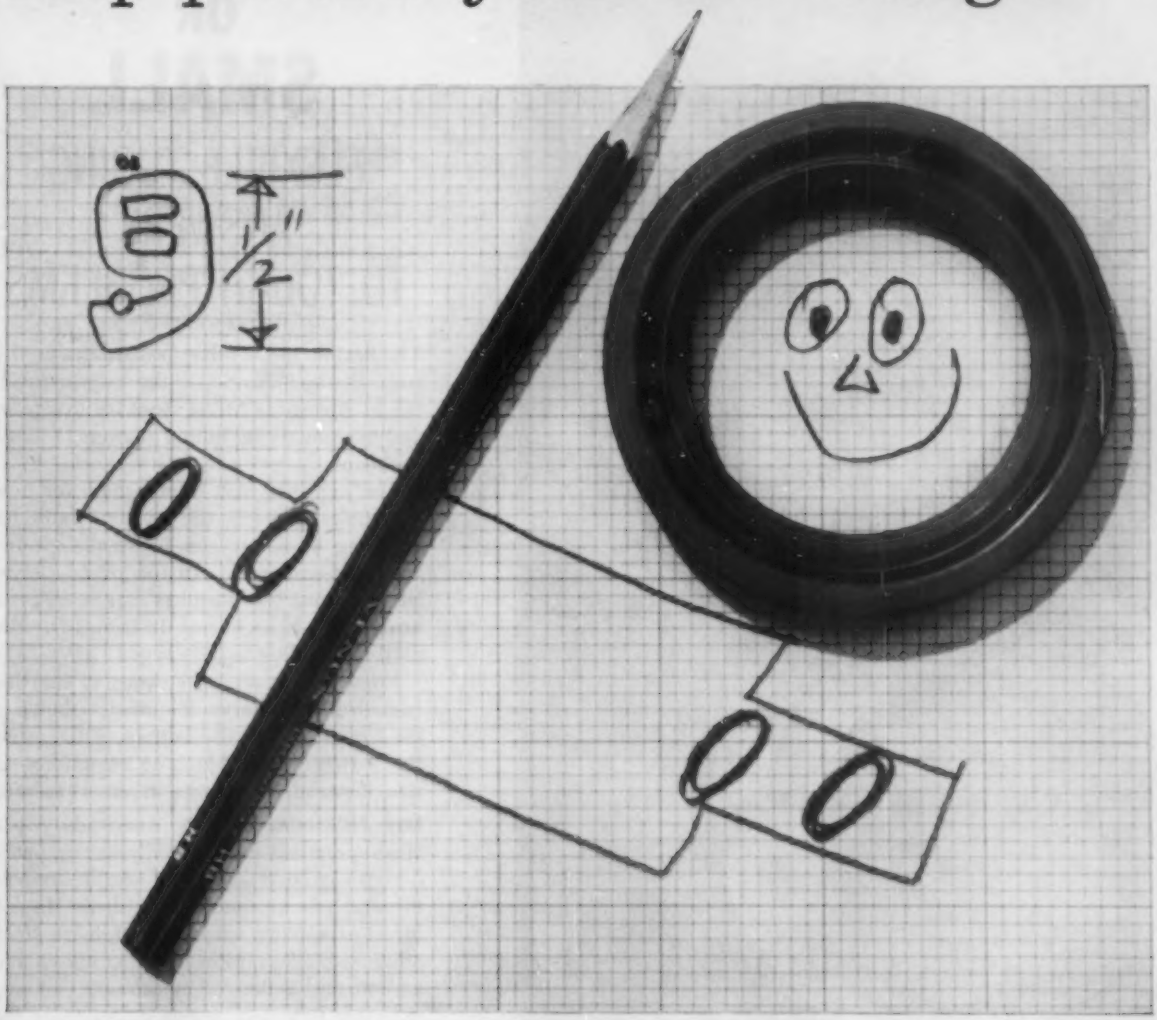

Special shapes available–and you name the material!

While your design is still on paper is a good time to let Johns-Manville help you determine the type of Clipper Seal that will give you most efficient machine performance. J-M has many design cross-sections to give bearings longer, better protection against heat, speed, leakage, dirt and corrosive chemicals.

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J-M Clipper Seals protect better . . . because they *are* better. Specially compounded to do each job, Clipper Seals provide maximum sealing ability, low torque, long life, easy installation and wide adaptability. For complete information, write to Johns-Manville, Box 14, New York 16, New York. In Canada: Port Credit, Ontario.

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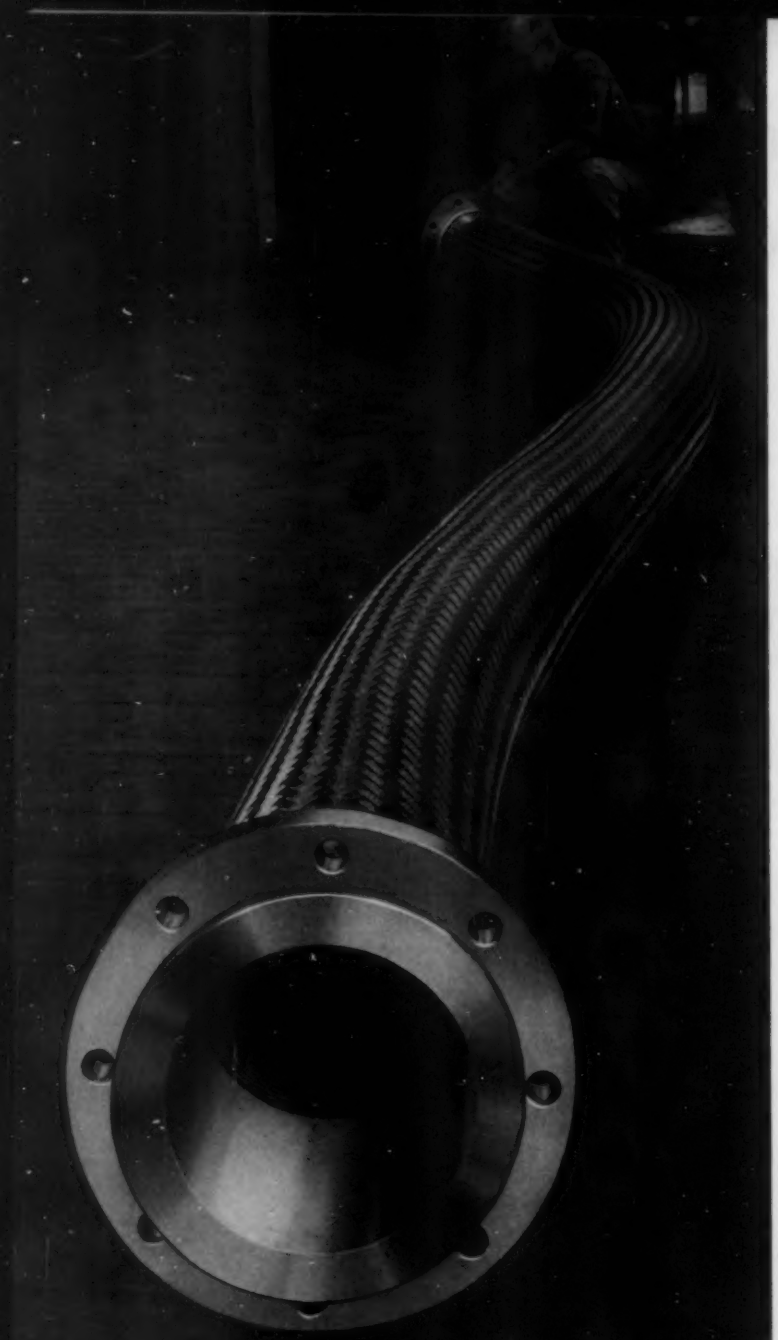


BIG OR SMALL

FLEXIBLE TUBING ANSWERS TO TOUGH PROBLEMS

The flexible metal tubing assemblies on this page give an indication of the scope of facilities at Anaconda Metal Hose for designing and manufacturing tubing answers to tough problems.

The big 16½-foot, 8-inch diameter tube in stainless steel at the left was built for handling liquid oxygen in missile ground handling equipment. In the photo below, left rear, are two stainless steel connector assemblies—14-inch and 10-inch I.D.—also used in handling liquid oxygen.

From such assemblies down to the tiny ⅛-inch I.D. Vibration Eliminator shown in the foreground at the bottom of the page, the variety of flexible hose assemblies—in size, material, and design—is almost infinite.

FREE TECHNICAL SERVICE. Anaconda Metal Hose specialists are constantly working with design engineers on special flexible connectors and hose to meet new problems. Having broad experience working in stainless steel, other steel alloys, Monel, copper alloys, aluminum, and Teflon,* they can save you considerable time and money in designing the flexible connector best suited for your needs.

Our specialists are available to you through Anaconda Metal Hose representatives in leading cities — see listing "Metal Hose" in the Yellow Pages. Or write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. *Registered trademark for Du Pont fluorocarbon resins.

88180

ANACONDA®
METAL HOSE

PRODUCT ENGINEERING HORIZONS

May 2, 1960

the CRACKED CRUTCH

Engineers are numbers men. Sooner or later, every engineer insists upon putting numbers to whatever is under discussion, to the irritation of Management, Sales, or the visiting peddler. It's so much more fun to talk in glittering generalities—"a new departure," "a more-economical design," "we'll talk about it later," "that's a detail"—you know the phrases.

It's tough to be concerned with numbers; they puncture balloons. But that's the analytical streak that characterizes engineers. It keeps the discussion somewhere near practicality.

The difficulty is that numbers can be wrong—just as wrong as generalities. It depends on the numbers. Watch yourself when you preface numbers with: *usually, generally, normally, for purposes of argument, to give you some numbers, let's assume, as I recall.* The apologetic or hedging phrase may salve your conscience, but it doesn't prove the numbers. Yet we *must* assume numbers in some kinds of analyses, then prove them right—we hope. And in other instances, we assume numbers that we couldn't prove if we had to. Then we end up with a "truth" that isn't a truth at all.

Our handbook, for example, shows the tensile strength of SAE 1010 steel as 67,000 psi. So we automatically picture the stress rising evenly to that number, at which point the specimen snaps. When challenged, we add the familiar stress-strain diagram, may even mumble about averages, stress concentrations, end conditions.

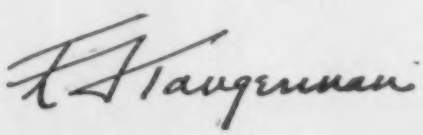
But if all variations are considered, the 67,000 psi looks rather questionable—and we're right back where we started. We generalize, take an arbitrary value and use it as fact. Usually, technology has improved enough so that this procedure is safe, although we often don't know how much testing established the value in the first place nor how accurate the testing was. It's in the handbook, so we assume it is true.

We make similar assumptions with regard to strengths, other properties and characteristics, manufacturing costs, tolerances, efficiencies. We quote them as facts, with precise numbers, when they're generalities, albeit technological ones.

In most cases, there is no harm done. The layman listening is impressed by our superior knowledge and isn't likely to use the numbers anyway. As some Spaniard said a long time ago, "In the land of the blind, one eye is king."

The danger can come if we go ahead with the numbers ourselves, without some current test or check. It was numbers, manipulated by statisticians, that made trouble in our missile programs, numbers used to predict performance. But the numbers—and the predictions—turned out to be wrong. Not until they were checked by test—field test rather than lab test—were all the environments encountered that showed the numbers to be wrong.

There is no such thing as a technological fact. Every one must be reexamined continually in the light of the new developments and the new problems. Numbers may be no more accurate than generalities—and they can be more dangerous. An unchecked number is a crutch—and a cracked crutch at that.



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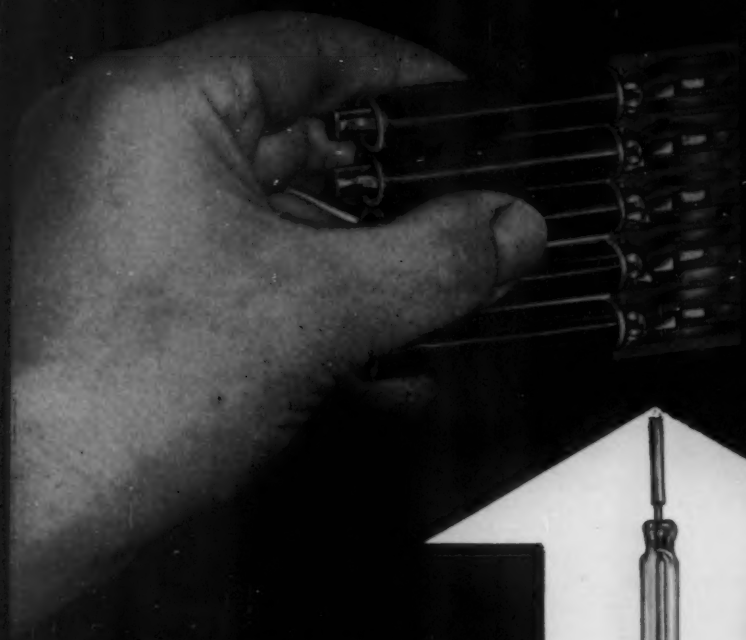

ACTUAL SIZE

Basic element of CLAREED relays is this switch capsule. A pair of magnetically operated contacts is hermetically sealed in an atmosphere of inert gas. The capsule combines extreme simplicity with high reliability and long life. It has excellent low-level characteristics.

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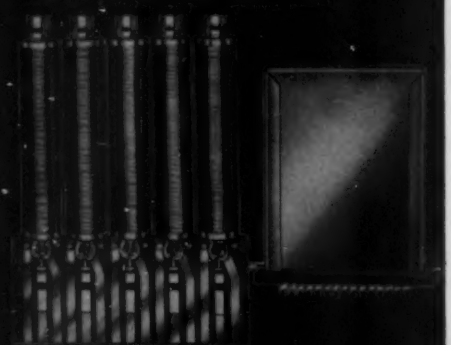

Here five relays, each containing two switches, are mounted on a printed circuit board. This assembly may be inserted directly into your equipment or enclosed in a flat pack container.

These six switches are clustered to form the core of a single electromagnetic coil, and encased in a cylindrical steel container.

CLAREED Sealed Contact Reed relays put you . . . the designer . . . in the driver's seat. They are simple in design, flexible in assembly. They are packaged and mounted to comply with *your* mechanical design configuration . . . even on your own circuit board. CLAREED relays are ideal components for transistor-drive applications, computers, data-processing and other high speed equipment.

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When only the best is good enough

ELECTRICAL ANALOG SIMPLIFIES HEAT-FLOW ANALYSIS

Electrical circuits serve here as simulators that predict behavior of the product under a large variety of complex thermal conditions. Author explains typical analogs that need only batteries, resistors and capacitors for operation.

MORTON SKLAROFF, *manager, process control, Eastern Research Center Div*
Robertshaw-Fulton Controls Co, King of Prussia, Penna

There are several similarities between the flow of heat and flow of electricity. But electricity is easier to produce and measure. Combine these two facts and you have the key to the electrical analog method of solving complex thermal problems.

First, to supply the basic heat-flow data, tests are run with the product prototype. Then an equivalent electrical circuit—corresponding to the block diagram of actual heat flow—takes over to predict the product's behavior under a variety of conditions.

Specifically, what the analog does is exploit similarities between heat flow and electrical current, heat capacity and electrical capacitance, thermal "Ohm's law" and electrical "Ohm's law."

Heat flow and electrical current—the basic elements in the analogy—are not, of course, truly equivalent; btu's are units of energy, and coulombs are units of charge. But each obeys similar mathematical laws.

Heat capacity of a mass, its btu's per degree Fahrenheit, is analogous to the farads of electrical capacitance—and the heat "leaks" to ambient just as a capacitor charge leaks to ground. Increasing mass increases capacity, and insulation reduces leaks. Heat capacity is defined as specific heat, in btu/lb per deg F, times mass of the part, in pounds.

The thermal counterpart of Ohm's law is $\Delta T = QR$, where ΔT is the temperature difference across the part, R is the effective thermal resistance (reciprocal of the heat-transfer coefficient), and Q is heat flow. The electrical Ohm's law is $E = IR$.

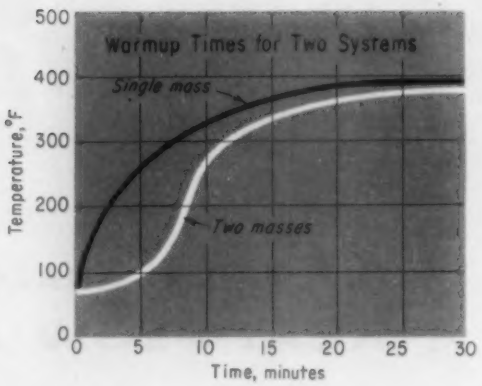
ANALOG DESIGN

The electrical analog is designed to simulate the response of the actual thermal circuit. The warmup or initial response is the condition most difficult to duplicate, because some of the heat is absorbed by the cool mass of the part, and the rest is dissipated to ambient. A simple thermal circuit—with only a single mass to absorb heat—is easiest to simulate because it has but one "time lag" (time delay while mass absorbs heat).

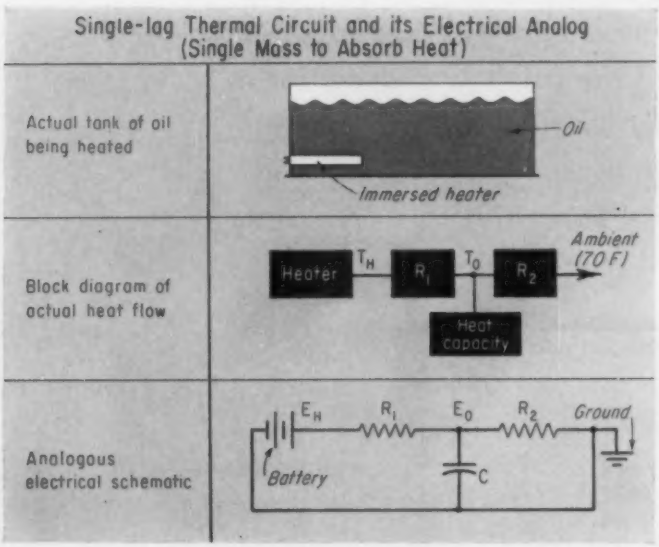
Thermal circuits with two or more separate masses to absorb heat have a separate time lag in each of the branches, and the mathematics can become unreasonably complicated. For such multiple-lag circuits, a trial-and-error

Analogous Quantities

Thermal		Electrical	
Unit of heat	Btu	Charge, Q	Coulomb
Heat flow, Q	Btu/min.	Current, I	Coulombs/sec
Temperature, T	°F	Potential, E	Volts
Resistance, R	°F per btu/min.	Resistance, R	Ohms
Capacity, C	Btu/°F	Capacitance, C	Farads



ONE-MASS AND TWO-MASS thermal systems respond differently during initial heating or other transient changes. The one-mass (single-time-lag) system has simple exponential curve. The two-lag system combines responses of two masses. The single-mass curve easily can be expressed mathematically for use in an analog, but the two-mass curve—far more complex—is better handled on the analog by trial and error.



ACTUAL HEAT FLOW is more complex than indicated, but this short-cut method gives reasonably accurate answers. Temperature T_H is heater temperature, assumed constant. Thermal resistance R_1 is effective resistance from heater element to oil in tank. R_2 is effective "leakage" thermal resistance from oil to ambient "Heat capacity" is heat needed to raise temperature T_0 of oil 1 deg F.

approach is more practical. These are the two basic techniques: calculation (for one-mass single-lag thermal circuit); and trial-and-error (for two-lag circuit.)

SINGLE-LAG CIRCUIT (TANK OF OIL)

Heat flow (heater-to-oil-to-ambient) can be simulated by electrical current (schematic in illustration above) if heat capacity of the oil is known, and relationship between average oil temperature T_0 and time can be established by test.

It is assumed that oil weighs 100 lb, tank mass is negligible, heater temperature T_H is exactly 500 F, final oil temperature is 400 F, and oil specific heat is 0.65 btu/lb per deg F. Heat capacity C is $100 \times 0.65 = 65$ btu/°F. Temperature-time data is plotted at top of this page.

Effective values of thermal resistances R_1 and R_2 can be calculated by simultaneous solution of two basic equations:

For initial response–

$$\text{Time constant}/C = R_1R_2/(R_1 + R_2)$$

where "time constant" in minutes is the time required to reach 63% of the oil's final average temperature. Time constant (from test data) is five minutes for this example.

For final state (when oil reaches 400 F)–

$$(T_0 - 70)/(T_H - 70) = R_2/(R_1 + R_2).$$

Heat flow has "leveled-out" because oil has absorbed its maximum amount of heat and circuit has only resistance left.

Substitute known values of T_0, T_H, C and time constant in the above equations:

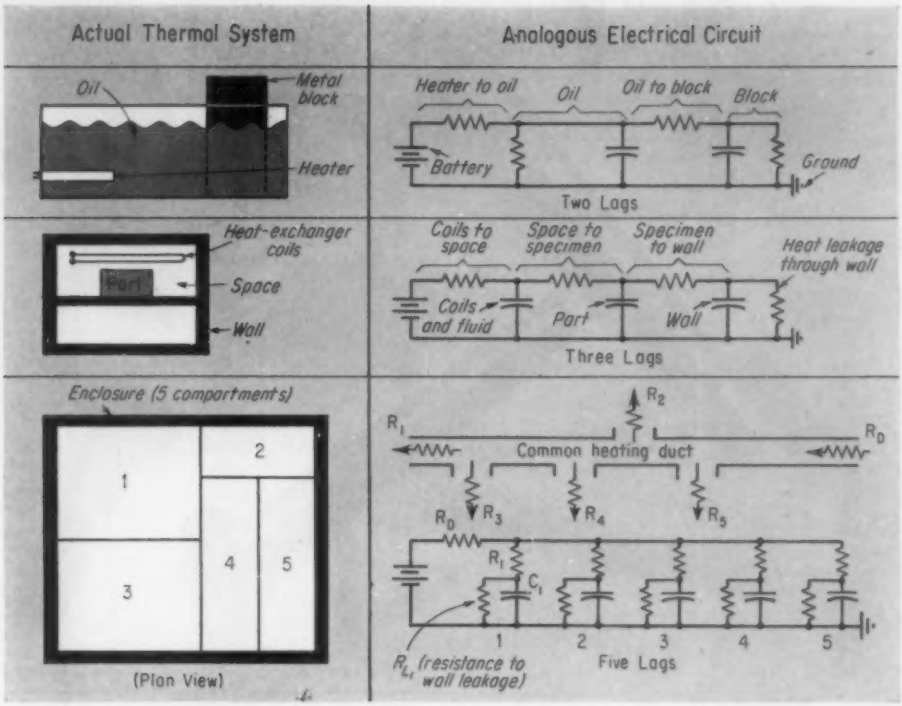
$$R_1R_2/(R_1 + R_2) = 5/65 = 0.077 \text{ deg F per btu/min.}$$

$$R_2/(R_1 + R_2) = 330/430 = 0.767.$$

Simultaneous solution shows that $R_1 = 0.1$, $R_2 = 0.33$ deg F per btu/min.

In designing an electrical analog, select electrical quantities that are easy to produce and measure. Practical values are: 1 v for each 10 deg F; 10^6 ohm for each 1 deg F per btu/min.; 10^{-6} farad for each btu/°F. But remember that the basic equations are affected by these "scaling factors." The equation for the final state becomes: $(E_0 - 7)/(E_H - 7) = R_2/(R_1 + R_2)$. The initial-response equation becomes: time constant, sec $= (C \times 10^{-6})\ (R_1 \times R_2 \times 10^6)/(R_1 + R_2)$.

Response time of the electrical-analog circuit will be



SIMPLIFIED ELECTRICAL CIRCUITS show basic heat-flow pattern of each thermal system by analogy. Electrical potential and current are analogous to temperature and heat. Electrical ground is analogous to ambient air; resistors represent conduction and convection flow-paths, and capacitors simulate thermal-absorption ability of mass.

10^{-2} sec for each minute of the actual temperature response. For instance, substituting 0.1 and 0.33 megohms for R_1 and R_2, and 0.65 microfarads for C, the time constant becomes 5×10^{-2} sec instead of 5 minutes. This high speed is one of the main advantages of the analog method. Many different combinations of temperature can be tried on the analog in a few minutes, whereas testing the actual tank would take hours.

TWO-LAG CIRCUIT (METAL BLOCK IN OIL)

This thermal circuit (see sketches above) is the same as the single-lag oil tank, except that another time delay—a block of metal extending above the oil surface—has been added. The metal block is a "load" on the original circuit, simulated by a capacitor and resistor as shown in the sketch.

Though it is almost impossible to predict the values for the two additional resistances, it is a simple matter to experiment with variable resistors until the right combination is found. For even more versatility, the capacitors can also be made variable.

The warmup curve for a two-mass (two-lag) system is shown on facing page. By substituting a square-wave (pulse) electrical generator for the battery in the electrical analog, the buildup and decay of voltage vs time can be observed with an oscilloscope. Careful manipulation of the variable resistors will usually reshape the electrical response curve to correspond with the actual temperature-response curve.

The absolute values for resistance obtained by this trial-and-error method will not necessarily be correct, but time constants and ratios of input and output voltages will be correct—satisfying the basic requirements for an electrical analog.

ACKNOWLEDGEMENT: The author wishes to credit two fellow engineers who worked on this project: Dudley D. Nye for his initial concept of the similarity between thermal and electrical units, and Phillip M. Connaught for his assistance and criticism.

For **REPRINT** of above article, just check P49 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: Two recent heat-transfer articles solve thermal problems in more conventional ways:

Infrared for Heating a Product, Feb 1 '60, p 39, compares radiant heating with convection, conduction, induction and dielectric heating.

When Air Is the Coolant, Feb 16 '59, p 54, shows how to estimate whether an assembly will run too hot, and whether the self-cooling methods of radiation or convection can handle the trouble.

And these recent articles covered pneumatic-electric analogies:

Pneumatic-electric Equivalents, Apr 4 '60, p 52, describes air devices that challenge electron tubes and resistors for control functions.

Fluid Amplifier, Mar 14 '60, p 17, reports on pneumatic amplifier that has no moving parts, uses jets of air to get 100:1 power amplification.

for cold-heading applications . . .

WHICH COPPER ALLOY?

To help you choose, the author ran special tests on the most common cold-heading alloys—and a few of the less common. His results, in ready-reference chart form, show the choice is wider than you think.

R J CHRISTINE, *metallurgical manager*
Torrington Division, American Brass Company

Copper alloys are ductile and easily work-hardened, and these two characteristics—common with most metals whose crystals are face-centered cubes—make them popular for cold-headed parts. In this process (see "Basics of Cold Heading," top of p 45) work-hardened wire is drawn into a heading machine and upset to the shape desired. The problem is: which copper alloy to choose among the many that are available? This article breaks down 14 suitable alloys into 6 basic groups, and explains the main factors controlling selection of one group over another.

The copper alloys grouped in the accompanying table are the most widely specified types for cold heading. Comparative data on these alloys are hard to find, so a series of tensile tests on the listed alloys was run to eliminate mill-processing variables as much as possible.

The table, which gives the results of these tests, has several features making it a useful guide to the right copper alloy for the job:

First: Each alloy is shown in two standard tempers, A (¼ hard) and B (½ hard). These designators denote the amount of mechanical strengthening the alloy has been subjected to before cold heading. Though it is assumed that the cold-heading process itself enhances these properties, the pre-heading values are widely used in design—to be on the conservative side. The A and B tempers are obtained by wire drawing: temper A represents about 20% cold reduction; temper B slightly under 40%. For these tests, a coil of each alloy was drawn to 0.250 in. dia, annealed, then half was drawn to a ready-to-finish size of 0.153 in. dia and the other half to 0.175 in. After reanneal, both half-coils were drawn to a final wire size of 0.139 in.—a common size for small parts.

Mechanical Properties of Copper Cold-heading Alloys

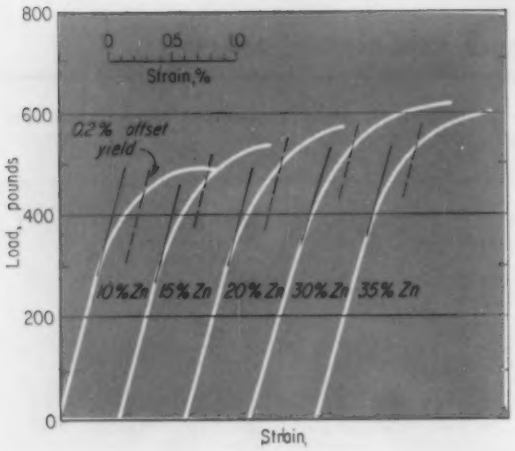
Alloy Group	Nominal Composition, %	Temper	Prop. Limit, psi x 1000	0.2% Offset Yield Str., psi x 1000	Tensile Strength, psi x 1000	Red. Area, %	Plasticity Index, %
Brasses							
Commercial bronze	90 Cu, 10 Zn	A	20.5	43.0	51.0	85	40
		B	39.0	57.5	64.0	81	61
Red brass	85 Cu, 15 Zn	A	23.0	49.5	55.0	82	42
		B	42.0	62.0	71.0	77	77
Low brass	80 Cu, 20 Zn	A	33.5	50.0	57.0	81	59
		B	44.0	65.0	76.5	79	58
Cartridge	70 Cu, 30 Zn	A	32.5	51.0	63.5	80	51
		B	48.0	70.0	82.5	73	58
Cupronickels							
10% Ni	88.35 Cu, 10 Ni, 1.25 Fe, 0.4 Mn	A	38.5	52.0	54.0	81	71
		B	56.5	76.5	79.0	80	72
20% Ni	79.5 Cu, 20 Ni, 0.5 Mn	A	34.5	57.5	60.5	83	57
		B	46.0	69.5	74.0	74	62
Nickel silvers							
18% Ni	72 Cu, 9.75 Zn, 18 Ni, 0.25 Mn	A	37.5	57.5	60.0	83	62
		B	39.5	64.5	67.5	78	59
12% Ni	65 Cu, 22.75 Zn, 12 Ni, 0.25 Mn	A	43.0	58.0	67.0	77	64
		B	50.5	81.0	86.0	73	59
Tin bronzes							
5% Sn	94.75 Cu, 5 Sn, 0.25 P	A	38.0	60.5	66.0	83	58
		B	50.0	80.0	87.5	79	57
8% Sn	91.75 Cu, 8 Sn, 0.25 P	A	44.0	64.0	76.5	81	58
		B	57.0	90.0	99.0	76	58
10% Sn	89.75 Cu, 10 Sn, 0.25 P	A	49.5	73.5	86.0	71	58
		B	66.5	101.0	111.0	69	60
Leaded copper	99 Cu, 1 Pb	A	20.0	40.0	41.5	69	48
		B	27.5	48.0	51.5	64	53
Silicon bronze	98.25 Cu, 1.5 Si, 0.25 Mn	A	34.5	54.0	55.5	81	62
		B	43.5	67.0	74.0	76	59

Second: The table lists a "plasticity index"—a useful indicator of the amount of cold work a given alloy will take. This index is the ratio of proportional limit to ultimate tensile strength, expressed in percent. A low value of the index says that a large part of the total stress range to fracture is devoted to deforming the alloy plastically. Thus an alloy with a low value flows more easily during cold heading, and parts made from it can be designed with greater shape complexity. For best formability, a low plasticity index should be coupled with a high percentage reduction in area—to minimize shear fracture.

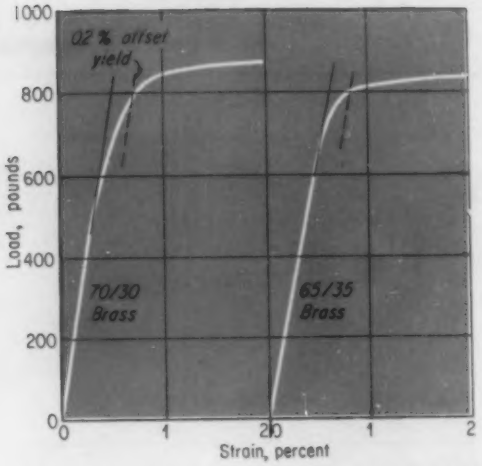
Third: The effect of alloying elements on mechanical properties is clearly seen in the table. The main purpose of alloying copper is to increase ultimate and yield strengths, making a nominally weak material suitable for structural applications. Alloying has other important effects (see next column), but the table shows how they influence the balance between increased strength and formability in the cold-heading process. Zinc additions, for example, give substantial strength improvements, while retaining a good formability (low plasticity index with high reduction in area). In selecting the proper cold-heading alloy, this interplay is usually the major consideration, with factors like corrosion resistance, color, surface finish and cost playing secondary roles.

What Alloying Elements Do

Addition of a second element, or a series of elements, to basic copper affects the crystal structure so that flow in certain directions becomes difficult except by going to higher stress levels. The effect depends not only on the element added, but its proportion in the matrix. Here, briefly, is a description of the influence the major alloying elements have on the engineering behavior of copper metal:



ALLOYING MAKES COPPER MORE WORK-HARDENABLE, as shown by these load-strain curves for five brasses with different zinc content. Each alloy was drawn, before tensile testing, to the same temper B (¼ hard: 37% reduction). Note how 0.2% offset yield load (stress at dashed-line intersection) increases steadily with zinc content. At 30% and 35%, both yield and fracture loads are about equal, though formability is not the same, as shown by experience.



WHICH IS MORE DUCTILE—30% zinc brass or 35% zinc brass? These load-strain curves on the two alloys in temper A (¼ hard, 18% reduction) show 70/30 cartridge brass is slightly more formable—because it begins to flow plastically sooner than the 65/35, yet continues to deform to a higher ultimate load. Thus the plasticity index (table, p 43) is lower. This, combined with higher percent reduction in area, makes 70/30 a better choice when shear is a major factor.

Zinc added to copper forms the brass family, with low brasses containing up to 20% zinc, high brasses up to about 35%. Adding zinc accentuates the work-hardening characteristic of copper—as the load-strain diagram on this page clearly shows: the more zinc added, the higher the yield strength obtained for a given amount of prior work hardening.

Malleability decreases with more zinc, but the choice for cold heading is sometimes hard to make among alloys of similar zinc content. A good example is 65/35 commercial yellow brass—its percent reduction in area is almost identical to that of 70/30 cartridge brass. One way to resolve the choice is to compare load vs strain for the two alloys: the curves above comparing the two show significant difference in their plastic-deformation behavior.

Increasing zinc content also affects other properties: Thermal and electrical conductivity decrease and color changes from the reddish hue progressively to the greenish yellow normally associated with brass. Both low and high brasses are subject to some dezincification when exposed to conducting solutions, and the high brasses tend to have trouble with stress-corrosion cracking—particularly in the presence of amine solutions.

Nickel can be added to copper alone or to copper-zinc alloys. When used by itself as the principal alloying ingredient, in the cupronickels, its purpose is primarily to improve resistance to stress corrosion and corrosion fatigue. Added with zinc, the element forms another alloy group—the nickel silvers. Here, the main purpose is to control alloy color; as nickel content increases, color moves from normal brass shades to silver-white. Nickel also helps retain good surface smoothness, important where subsequent plating is specified. Although corrosion resistance is improved as with straight cupronickels, dezincification can still be a problem. Though both cupronickels and nickel-silvers have high percent reduction in area, their slightly higher plasticity index tends to limit their use in cold heading to parts requiring exceptional corrosion resistance.

Tin is the principal alloying element in a group of alloys most often termed phosphor bronzes. High tensile and yield strengths are the major contribution of tin additions, along with excellent fatigue resistance. Electrical and thermal conductivities drop quite sharply as tin content increases. Tin content also imposes limitations in two types of service environment: Under thermal shock, there is a tendency to cracking, particularly if the part is under appreciable load; stress corrosion may occur when tin content is high, though stress-relieving before use minimizes this problem. For cold heading, the biggest advantage of phosphor bronzes is their favorable combination of low plasticity index and high reduction in area, second only to the straight brasses. Note, however, that for a 10% tin alloy given temper B (see table) the percentage reduction in area is low, indicating susceptibility to shear fracture.

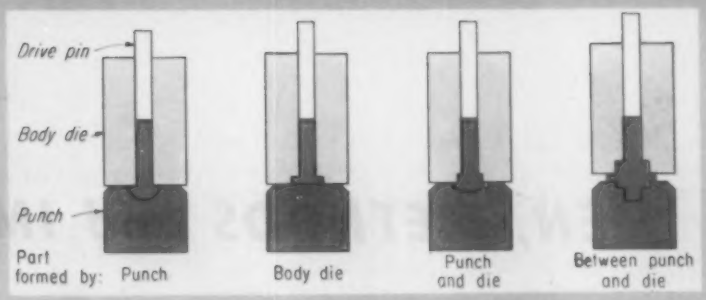
Lead enhances machinability of copper by acting as an embrittling agent, correspondingly reducing the percent reduction in area but with little effect on the plasticity index. For cold heading, this means that even though the plastic range is great, there is a limiting amount of work hardening that can be reconciled with shear strength. Lead added to copper seldom exceeds 1%, can go as high as 4%. These alloys are not recommended for shapes where shear forces are predominant in the cold-heading operation.

Silicon in amounts of 1 to 4% not only adds toughness to copper but improves ductility. Thus silicon bronze has a combination of plasticity index and reduction in area

The Basics of Cold Heading

■ Cold heading is a high-speed process that controls flow of metal within the confines of predetermined die shapes. This controlled flow is the antithesis of the competitive screw-machine process: The screw machine removes metal to obtain the desired end-product shape; cold heading, instead of wasting material, redistributes the stock into the desired shape. Coiled rod or wire is fed through straighteners into the heading machine where it butts against a stop and is sheared to length before forming in the dies.

The actual forming of the blank or slug is usually accomplished by a combination of a body die and a punch, although there are three other ways: the head can be formed wholly inside the body die, between the body die and punch, or within the punch (see sketches). The versatility of die design allows for intricate parts to be formed by one blow of the punch, or by a combination of blows in multiple-station heading, with two-blow heading being most common. Hollow sections can be formed by flowing the metal over a mandrel, as in the case of an extruded rivet.



For simple parts like screws, rivets and bolts, cold heading has no competition. With speeds up to 400 pieces per minute and higher, the process is cheap and fast. Die sets are not expensive and set-up time is relatively inexpensive. Utilizing large coils of wire, the set-up delays are held to a minimum. Scrap is incidental and not a factor in the process.

The use of secondary operations and the versatility of the process allow headers to compete against parts traditionally made by screw machines. Closer-microinch finishes can be obtained by cold heading without increasing costs. Another large factor in the competitive edge is the delivery schedule. High-speed headers can run off a million pieces in a minimum of time, include secondary operations, and still offer very close delivery. Properties are improved by cold heading, often an important factor. ■

favorable to cold heading, and is well suited to impact applications—particularly where very low temperatures are met, as in cryogenic equipment. Lower silicon bronzes tend to work-harden less rapidly than those with higher silicon content, so are preferred when cold-headed parts of these alloys require secondary operations like roll-forming of threads.

Upset Ratio Is Important

From data in the table and the previous discussion of alloying elements, it's clear that all the alloy groups selected represent ductile material suitable for cold heading. Often, however, the precise strength level needed or the exact service conditions are not known. Then, the best guide is the approximate amount of cold work that will be required to form a given upset. This can be simply expressed as the upset ratio, the ratio of final upset diameter to that of the original wire diameter. Three values of the upset ratio are controlling:

• **When the ratio is 2 to 3,** only one or two blows are usually necessary and the choice of material is not critical. Any alloy from the table, in any tempers, will be suitable.

• **When the ratio approaches 4.5 to 5,** two or more blows are necessary and selection of material becomes critical. See sample problem in the adjoining column.

• **For upset ratios over 5,** multiblow or progressive heading must be employed and annealing between blows may be necessary. Progressive headers also present certain lubrication problems because of the tendency of copper alloys to stick and gall in the dies. For multiblow heading, it is recommended that only alloys with the most favorable combination of plasticity index and percent reduction in area be selected from the table.

Sample Problem

Selection of an alloy for a given job should leave several alternates for refining the job. Assume an upset of 4.5 times the wire diameter is specified, using a wire in A temper (¼ hard) 70/30 cartridge brass, with a nominal 65,000-psi tensile strength. By trial heading, it is found that the heading machine won't handle it without shearing in the upset. Inspection of the table shows two obvious choices: either 90/10 or 85/15 red brass in a comparable temper. A third choice would be to cut the initial hardness on the 70/30 below temper A to ¼ hard, thus effectively widening the plastic range. But if shank strength must be in the neighborhood of 65,000 psi, none of these three choices will do. A logical choice would then be the tin bronze group. It combines strength with high percent reduction in area and moderately low plasticity index, a good combination for cold heading.

EDITOR'S NOTE: Articles on application of copper and its alloys to various engineering problems include:

For Best Results with Printed Wiring, Apr 4 '60, p 57—Once choice has been made over conventional wiring, article gives answers for specific design problems based on latest industrial experience.

Copper Alloys for Those Small Tubular Parts, Feb 2 '60, p 44—Easily drawn, swaged, flared, pierced, bent and joined—copper alloy tubing can be shaped to solve many design problems.

Manganese-Copper High-damping Alloys, May '56, p 135—Addition of up to 38% copper gives manganese unusual damping capacity and provides an alloy that has the strength of steel, and can be hot- or cold-worked by many methods.

Colored Finishes for Copper, Dec '56, p 135—Discusses natural finishes obtainable through combinations of chemical conversion and mechanical treatment of surface. Details given on each process.

MEN, METHODS and IMAGINATION

Successful product engineering—from first idea to production run—depends most on the men and their ability. But they must have a strong engineering management to back them up with facilities, trust, and a versatile organizational structure. An exclusive interview with a top design executive came up with this valuable advice to engineering management.

RICHARD M KOFF
Assistant managing editor

START WITH MEN: The most important product of an engineering department is not drawings or specifications or prototype models—it's ideas—and man is the only one who can produce ideas.

Start with a project manager (or chief engineer, or project engineer, or whatever the title in your company). He's the key man because he is in complete charge of the attack on any particular problem. He must be technically able, yes, but his primary responsibility is administrative.

Once the problem has been defined (more about this later) and the decisions made about quality or quantity, direction, cost, budgets and so forth, the project manager is on his own. A project requires this singleness of direction and purpose because as day-to-day problems arise and are solved it is very easy to get sidetracked, bit by bit, until the result has no resemblance whatever to the original goals. This chipping away at the goal can only be resisted by starting with a clear concept in one man's mind.

The Reactionary Manager

And so the most important function of a project manager is to recognize and maintain the planned pattern of development—to resist changes in the original specifications—to be, in effect, the most reactionary man on the staff.

To help him in this (and, salesmen to the contrary, an enthusiastic engineer is nearly irresistible) you can provide a formal progress report. The report carries the usual progress information but it should also include a clear statement of the original goals and require detailed explanation of any suggested amendments. Putting the reasons for changes on paper has a remarkably inhibiting effect on project wandering.

Obviously not every engineer is cut out to be—would even want to be—so reactionary. But there are plenty of other jobs just as important to project success. Good R & D comes only from good R & D people. Good design comes from a different man altogether. Put an R & D man on design work and you're going to be in serious trouble with delayed schedules and knee deep in experimental prototypes. Put a design man on R & D and he'll be so bogged down in details a project will never really get off the ground.

These aptitudes are nontechnical. Personality and character have far more to do with what a man likes and can do best than education or experience. And these aptitudes can be measured. Psychologists have devised tests—if you can define your needs clearly enough—to separate the R & D man from the designer or administrator. They are remarkably successful at it and any company that does not use them is overlooking an important service. Where the staff is large enough to require a full-time personnel manager, get a psychologist for the job.

The Project Definition

You've got your staff and each man is in his best position. Now what? How do you start?

Someone suggests, just dig in. The salesmen or your customer have defined their needs, the staff should figure out a way to satisfy them.

This is the biggest cause of product failure today. Few salesmen and no customers are capable of defining their needs in objective terms. They're too close to the problem, too influenced by past experience in the field, their customer's complaints, their competitors' successes. They are hamstrung by internal company policy and unaware of advances in other fields that might apply—with revolutionary results.

So first you analyze the project. Is it research? Development? Design? Define the problem and its goals—not necessarily the means of achieving the goals. That's for R & D to suggest. Is the problem chronic and beyond control? Imaginary? Attributed to the wrong causes? Are the goals realistic?

If you can get people to just sit and think about definitions and specifications rather than their own ideas of how the product should look—or what their competitor's product is—then you've made a long step to objectivity.

The Technical Survey

But even so, few people know what they want, much less what they need. And this applies in the engineering and commercial world just as much as it does on the consumer market. So some companies make a full-fledged technical survey. The technical survey is similar in principle to the market survey but is only secondarily concerned with marketing or selling aspects.

The technical survey is made by engineers. Their job is to specify a succesful product—its function, performance, competition, price and, if possible, its predicted cost for the proposed manufacturing plant and method. They must pay close attention to in-the-field aspects. Who uses the product? What maintenance and spare parts are necessary? What will be the effect of life and downtime?

It is vital to get the right man or group to do the survey. The man must have a completely open mind. He is a reporter more than an interpreter—a sponge, not a filter. Put a design engineer on a technical survey and he will invariably come back with a confirmation of what he wants to do.

This is not a conscious deception. The same forces operate on him as on the salesman. They cannot help knowing the answers before they start—or at least reaching an opinion—and this will subtly influence the phrasing of questions and the selection of material for the final report.

The technical survey must be a fact-finding expedition. Later, committees will evaluate and make the decisions.

The survey group finds out what people in the field think about tomorrow's needs. This is a predictive report and so they must interview or do library searches to discover what research is being done, by whom and how soon it will reach a commercial stage. As a sideline the survey group may do an economic analysis of production equipment for the anticipated product. Capital investment must be weighed by the same standards as any other cash investment.

All this information is gathered and reported. The methods, committees and applied imagination then needed to reach final decisions have been discussed in the many excellent management texts available. They don't need repetition here. But there is one more important point.

Design is a continuing problem. It does not stop at some fixed place or time and announce with finality that the product is now, and will continue to be, optimum.

The world of raw materials, components, labor, is in a constant state of flux and Purchasing or Manufacturing cannot know how to swing with the tide. Only Engineering knows the reasons for the many individual decisions along the way to the final design. These decisions were based on facts at that time. Changed facts must be taken into account as they occur, and "taking into account" is an engineering function. This responsibility must be clearly and explicitly assigned.

This also applies stringent requirements on the original designers. As far as possible they must pursue all the alternative paths toward optimum design, taking into account the various situations in which Purchasing, Manufacturing or Sales may later find themselves. In effect, Engineering makes many designs—not one—and clearly delineates the circumstances in which each is optimum.

It may not be easy to get manufacturing engineers to give up these priveleges, or responsibilities of "taking into account." Traditionally they have taken great pride in this redesign function. But such men should be consulted in the original design. Their contributions are part of true product development. They must assist in the preparation of detailed purchase specifications, clearly indicating the limits of acceptable performance as well as the economy-versus-cost relationship. They must be certain that parts, methods and materials used in the prototype are truly representative of the later production run.

Engineering must be able to set up a preproduction run under its own supervision. Production models, as near as possible, represent the final product and can be use- and environment-tested to prove the correctness of design.

Engineering then releases a set of drawings and instructions that are detailed and complete. The product will perform as specified.

EDITOR'S NOTE: Three related articles will be of interest to engineers facing the problems discussed here:

How Good Are Engineering Aptitude Tests? Nov 30 '59, p 32—testing agencies and personnel departments tell what the tests are like and offer some warnings to the unwary.

The Technical Survey—Why and How, June 15 '59, p 38—the systems engineering approach to market research on radically new technical products.

The Yardsticks for Research Success, Oct 19 '59, p 34—three indices of new product profitability used by top management.

europe's new cars feature COMPACTNESS with comfort

This year's International Auto Show demonstrates the latest results of European designers' sharp eyes for saving space. Here are details on how Jaguar, Austin and Lancia have solved some basic design problems.

PS... The annual International Auto Show in New York is, among other things, a display of the diversity possible in automotive design. In the years since passing of the Franklin and the Cord, American auto design has been concentrated on watercooled, front-engine, rear-wheel-drive cars (notable exception to this is Chevrolet's rear-engine 1960 Corvair). The increased interest in US compacts should result in a variety of unusual designs attempting to produce maximum passenger space with a minimum over-all length.

Meanwhile, European autos have, for a variety of reasons, usually been smaller, and the space problem has received continued study. The design details illustrated here are a few of the more interesting solutions of how to make 'em smaller on the outside and bigger on the inside—and to go on improving roadability and performance as well.

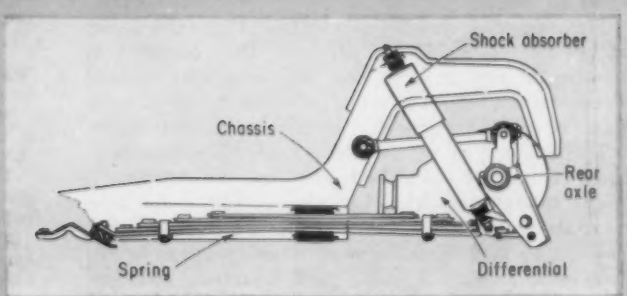
Austin

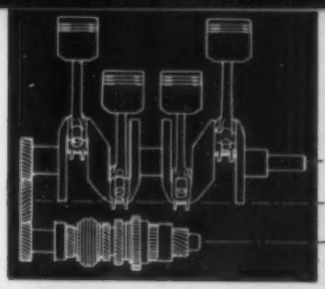
The 850 combines and simplifies the components that normally detract from the usable volume of a car. This provides a comparatively large passenger space for such a small (55-in.-wide by 120-in.-long) car. Combining the engine, transmission and differential into one transverse package minimizes the space required for the power train. The rubber springs at front and rear reduce to a practical minimum the space required for suspension components. The Austin Motor Company Ltd, Longbridge, Birmingham, England.

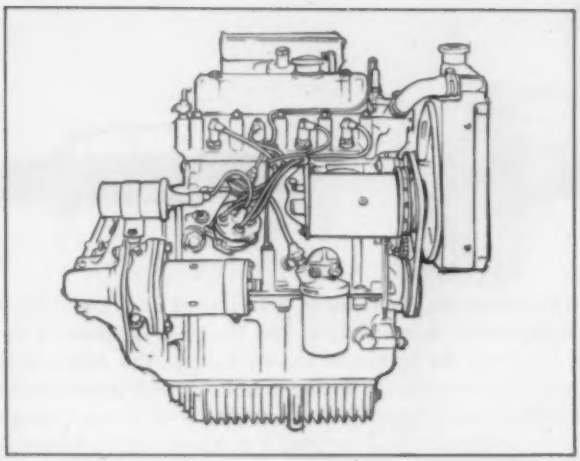
VARIABLE-RATE SPRING consists of a rubber element 5.25 in. dia and 3.25 in. deep. This is sandwiched between a small conical stamping attached to the suspension link and a larger conical stamping attached to the chassis. Movement of the suspension wedges the smaller stamping into the rubber spring. As the cone is wedged deeper into the rubber element (under full-load conditions, for example) the spring rate is increased. By varying shape of the cone, the relation between movement and displacement of the rubber can be varied to change the spring rate by more than 2:1. The rubber spring provides a high load capacity in relation to size and weight, plus a hysteresis characteristic permitting use of a smaller than usual shock absorber. Each unit weighs approximately 2.0 lb (0.72 lb for steel stamping; 1.28 lb for the rubber spring).

Jaguar

The Mark 2, 3.8-liter sports sedan is designed to give comfort of a 4-door sedan with performance of a sports car (225-hp, 120-mph top speed). Combining such qualities in a car approximately the size (180 in. long) of the US compacts, requires particular attention to suspension and power transmission. Produced by Jaguar Cars Ltd, Coventry, England.

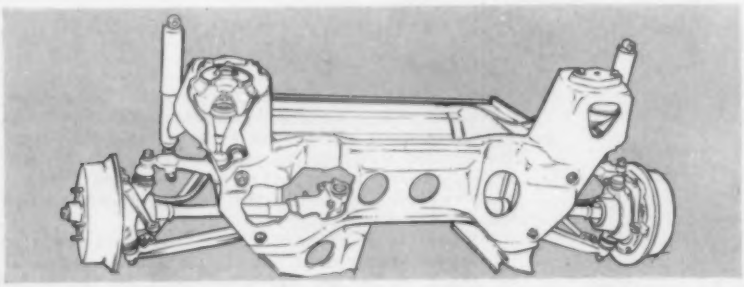


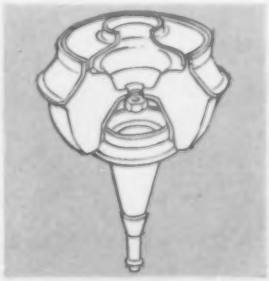


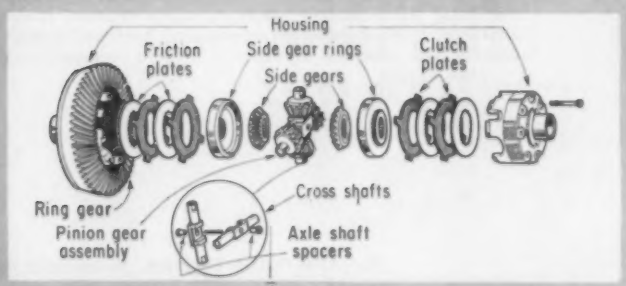


ENGINE PACKAGE is mounted transversely ahead of the front wheels. Power is transmitted from the crankshaft through a single-plate clutch. A helical gear, which slides over and rotates on the input shaft to the clutch, drives the transmission through an idler gear. The primary transmission shaft lies directly beneath the crankshaft; secondary shaft is forward of the primary but in the same plane. Also in same plane, but to the rear, is the differential—connected to the transmission by spur gears.

From the differential, power is transmitted to the half-shafts through a pair of bonded-rubber Hooke joints. The light-alloy finned sump serves as a common reservoir for oil lubricating both engine and transmission. Spur gears replace the spiral-bevel ring and pinion usually used in differentials. This eliminates need for hypoid lubricants.





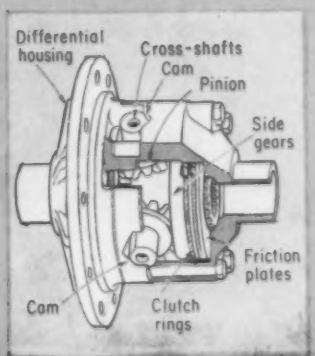


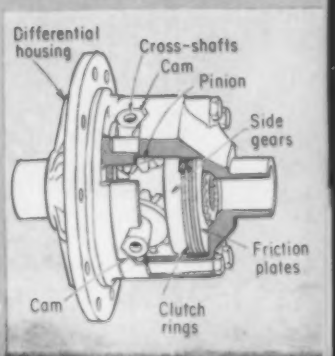
LIMITED-SLIP DIFFERENTIAL prevents spinning of either rear wheel if it leaves the road or loses traction (on ice, sand, oil patches). Heart of slip-control system is divided cross-shaft, which permits pinion to move transversely to operate clutches that control the axle shafts.

When car is traveling straight ahead, driving forces move the cross-shafts up the ramp of cams cut in the differential housing. This applies a load to the clutch plates and restricts the differential action. The torque ratio between the axle shafts is then based on the friction in the differential and the load applied to the differential.

When car turns a corner, the differential pinion gears become a planetary set with the side-gear on the inside of the turn becoming the fixed gear of the planetary. The outer side-gear overruns because the outside wheel travels a greater distance. The pinions are forced to rotate but, since they are restricted by the two side-gears, they move the cross-shafts back down the cammed surface, relieving the load on the clutches. Full differential load is thus restored and the wheels are free to rotate at different speeds.

REAR SUSPENSION springs are semielliptic cantilevers with rubber inserts between ends of the spring leaves. The rear of each spring is rolled into an eye enclosing a rubber-steel bushing—bolt through this bushing connects spring and a bracket welded to bottom of the rear-axle tube. A rubber pad on the front end of the spring bears directly on an inclined plate bolted to the chassis. No suspension members are needed behind the axle, thus increasing usable volume. Center of spring is clamped between rubber pads at the chassis rear. Torque arms (large rubber-steel-bonded bushings at each end) are fitted between two brackets, one welded to top of rear axle, the other welded to a body crossmember. These torque arms control position of rear axle during bump and rebound. Lateral position of axle is controlled by a rubber-mounted track rod fitted between axle and chassis.

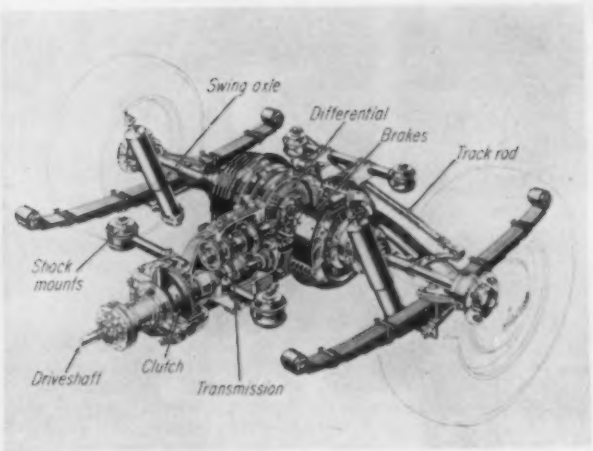




europe's new cars feature COMPACTNESS with comfort

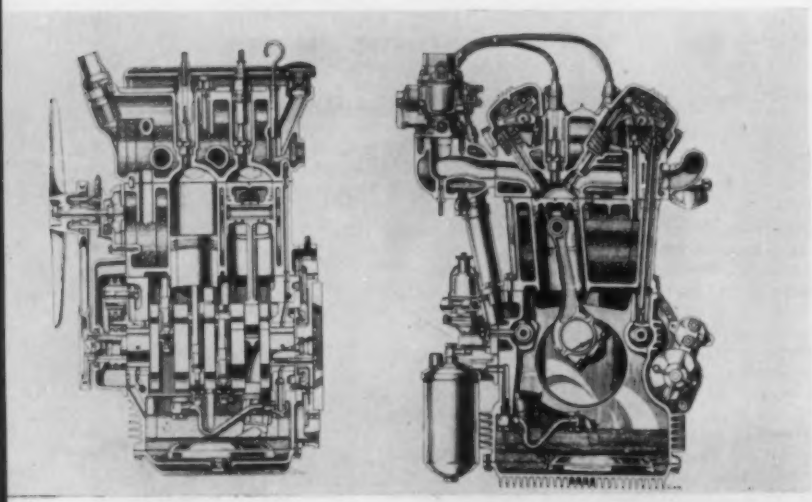
Lancia

FLAMINIA and APPIA models are produced in a variety of body styles by the manufacturer and independent body-makers. The Flaminia is powered by a V-6 engine and incorporates the transaxle shown below. The Appia series incorporates the square-four engine, illustrated at bottom, with a conventional live rear axle and differential. These components are used in cars ranging from 162 to 191 in. long and capable of carrying 2 to 6 passengers. Developed by Lancia & Co, Turino, Italy.

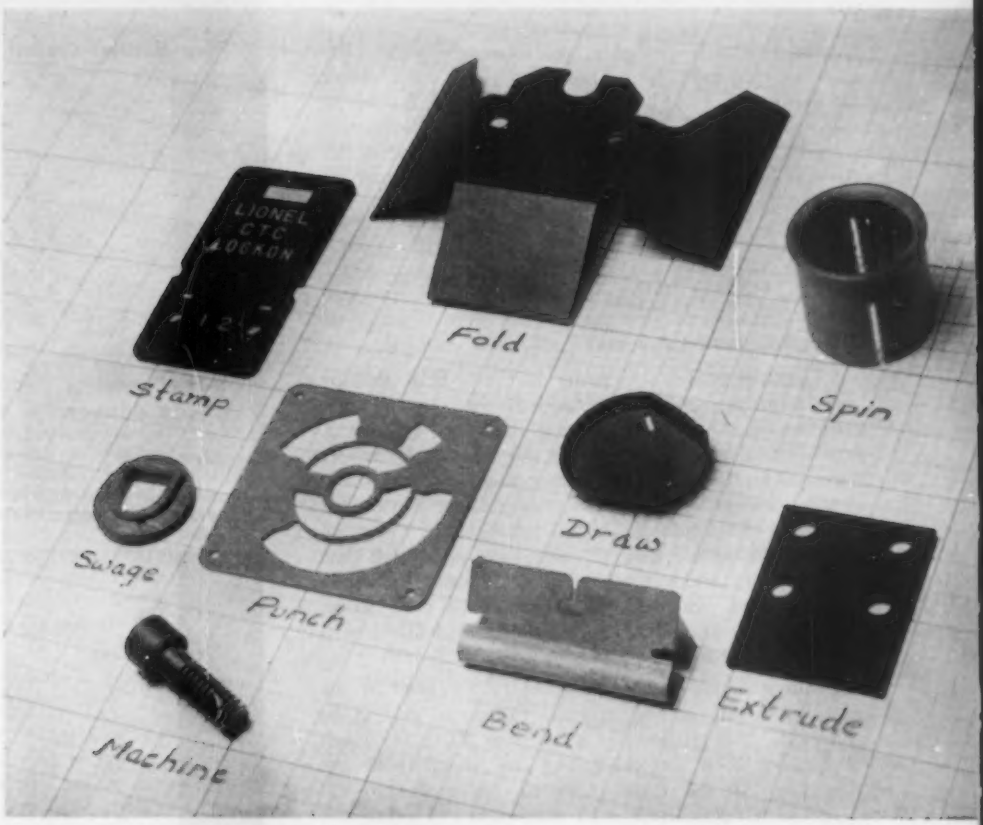


THE TRANSAXLE combines clutch, transmission differential and brakes in a single unit attached to the chassis by rubber shock mounts. Swing axle transmits driving and braking forces to the rear wheels, which are suspended on longitudinal leaf springs. A curved tube and track rod, mounted behind the transaxle, control wheel spacing and positions.

Single-plate or automatic clutch transmits power to the 4-speed, synchromesh gearbox. Differential is flanked by finned brakes and universal joints for the swing axles. Among the many advantages of the transaxle design are: better ride and roadability because of the improved sprung/unsprung weight ratio; reduced hump or tunnel in passenger space, possible because driveshaft does not follow wheel movement; improved weight distribution achieved by moving clutch transmission package to rear.



SQUARE-FOUR ENGINE is actually a narrow, staggered-V arrangement with one cylinder head. This shorter engine can be mounted in a much smaller space, providing more room for passengers in the front seat. Short crankshaft has two main bearings and four connecting-rod throws. Heavy reinforcing web at center does not support crankshaft but stiffens crankcase. Overhead valves are actuated by chain-driven dual crankshafts, through pushrods and rocker arms. Transverse valve arrangement provides adequate space between pushrods for intake and exhaust passages. Connecting rods are split diagonally to allow piston and connecting rod to be withdrawn upward through the cylinder. This permits repairing pistons and connecting-rods without removing the crankshaft. The 1099-cc (66.5 cu in.), 8:1 compression-ratio engine develops 54 bhp at 4900 rpm.



THESE 9 WAYS FOR . . .

SHAPING VULCANIZED FIBRE PARTS

EARL A RUSSEL, *chief engineer, Spaulding Fibre Company, Tonawanda, NY*

The properties of vulcanized fibre, one of the oldest plastic materials, are well known (*PE*—Feb '57, p 194)—but precise information on how to design parts from this low-cost material is harder to find. What forming methods can be chosen? What limits do these methods impose on design? How can vulcanized fibre parts be joined? How does moisture affect their dimensions? This article gives the answers to these and other questions, along with a brief description of the material and how it's made.

What Is Vulcanized Fibre?

Its primary properties—high strength, abrasion resistance, and toughness—result from an irreversible catalytic chemical conversion of fibrous cellulose that occurs when a cellulosic sheet is dipped in zinc chloride. Plies gelatinized by the ZnCl are laid together for the desired thickness, the chemical reagent is leached out, and the sheet or roll is dried and calendered smooth.

Resulting fibre product has a characteristic grain direction because the paper machine that makes the cellulosic sheet orients more fibrous material lengthwise than crosswise. This gives directional properties as shown in Table I; the table also lists the three standard grades—commercial, bone and electrical insulation—which vary in characteristics because of different degrees of gelatinization. Prolonged chemical action breaks down more of the cellulose structure, giving higher density, hardness and wear resistance.

Moisture is both a blessing and a problem for vulcanized fibre. Its natural moisture, about 6%, gives the

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material toughness, resilience, and forming qualities. Reduce moisture content, and the material can warp, shrink and become hard and brittle; increase moisture, it tends to warp, expand, and lose stiffness and electrical insulating properties. How fibre adjusts its moisture content to the surrounding atmospheric humidity is seen in Chart A. Dimensional changes resulting from these adjustments can be predicted from Chart B. A good rule of thumb for design: For each percent change in moisture content, expect 1% change in thickness, 0.25% change in width, and 0.1% change in length.

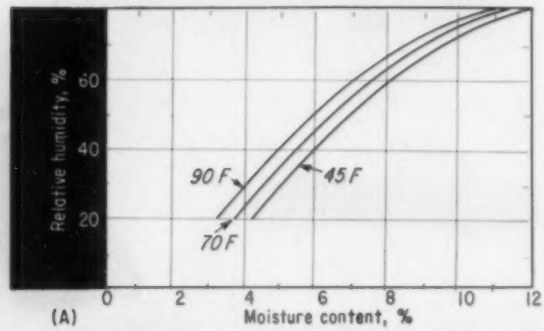
Which Fabrication Process?

Vulcanized fibre is sufficiently ductile to be formed by many common metalworking methods: swaging, spinning, extrusion, flat punching, drawing, bending, or folding. Preconditioning or preheating of the sheet is sometimes necessary for these processes, depending on shape, thickness and amount of distortion required. If the part cannot be formed dry in cold dies, the part may require (1) dwell time, dry, in heated dies, (2) prewetting plus dwell time in heated dies to restore normal moisture content. Preconditioning and heated-die forming add to cost. Here, method by method, are data you will need to design parts for minimum cost.

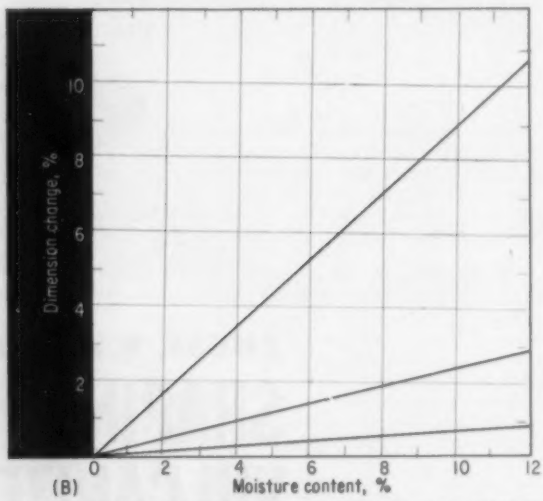
Bending should be done parallel to the grain of the fibre; min radii, as well as angle tolerances, depend on thickness. This relationship is given in Table II, which also shows when preconditioning and heated molds are necessary. As the table indicates, tolerances on 90° bends are not close: there is too much inherent springback. Overforming helps somewhat and closer tolerances than those given can be specified, but at greater cost in tools, if not in piece price. One low-cost way to hold better tolerances—design a bridge into the angle at intervals to stiffen the whole shape. Tubes can be bent to a limited degree; an inner bend radius of 10 times tube OD is about the limit.

Drawing to a cup shape can be done in a simple punch press, with material dry, in thicknesses of 0.015 in. to 0.030 in. to a depth of approximately $\frac{1}{8}$ in. Deeper cups can be made by blanking and forming but with wrinkling varying with depth and diameter. For thicknesses of 0.030 to $\frac{1}{16}$ in., wetting is required. Because severe draws require greatest wetting, they require longest drying time and therefore increase costs. A typical severe draw would be a

How Moisture Content Affects Fibre Dimensions



MOISTURE CONTENT of vulcanized fibre changes with ambient relative humidity. When RH changes, approximate change in moisture content may be read from above curves. Additional curves, roughed in by interpolation, will give reasonably accurate figures for design. Moisture content change is then used in Chart B to get dimension change.



DIMENSIONS INCREASE as fibre picks up more moisture from the atmosphere. Percent change in H_2O content from Chart A is entered on this chart and carried vertically to the appropriate dimension curve. For example: On a 90° day, RH drops from 67% to 51%, which dries vulcanized fibre so that its moisture content drops from about 8% to 6% (Chart A). From Chart B, this causes a contraction of 7—5.3=1.7% in thickness, or 0.017 in./in. of thickness.

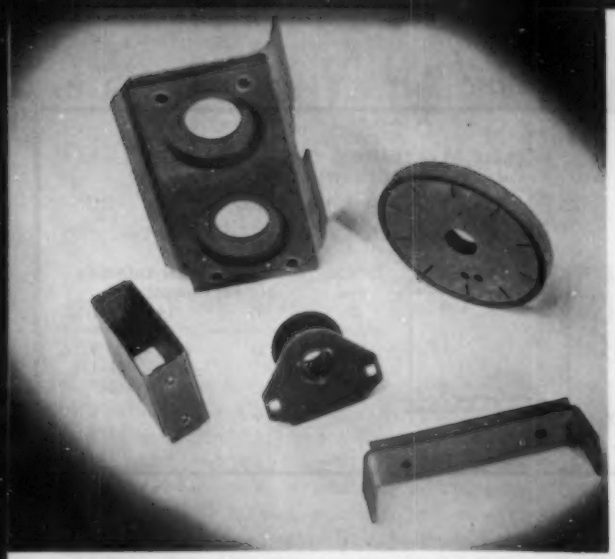
TABLE I — TYPICAL PROPERTIES OF VULCANIZED FIBRE
(for 1/16-in. stock; all properties slightly lower for higher thicknesses)

Property	FIBRE GRADE Commercial	Bone	Electrical Insulation
Specific gravity	1.25	1.40	1.25
Tensile strength, psi x 1000	7.5/13.5*	8/14	7.5/13.5
Flexural strength, psi x 1000	13/15	14/16	13/15
Dielectric strength, v/mil	225	225	350**
Hardness, Rockwell scale	65	85	65
Thermal conductivity, btu/hr-ft²-°F/ft	0.168	0.168	0.168
Specific heat, btu/lb-°F	0.403	0.403	0.403

* Crosswise/lengthwise ** For 0.005 to 1/32 in. thickness

TABLE II — TOLERANCES FOR RIGHT-ANGLE BENDS
(parallel to grain)

Thickness, in.	Min inside radius, in.	Tolerance, deg	Process
1/32	1/32	± 5	Predampen, punch, dwell in heated dies
	3/64	+10 − 5	Normal punch-press operation
1/16	1/16	± 5	Soak, pile, mold in heated dies
		+10 − 5	Predampen, punch, dwell in heated dies
3/32	3/32	± 5	Soak, pile, mold in heated dies
	5/32	+10 −10	Predampen, punch, dwell in heated dies
1/8	1/8	± 5	Soak, pile, mold in heated dies



FIVE METHODS FOR JOINING FIBRE parts to each other or to dissimilar materials like phenolic laminates or sheet metals. Clockwise, from left: metal rivets, fibre tube-grommets, shrink fit (outer ring soaked in water to enlarge it, then dried in place), fibre rivets, and fibre tube-grommet combined with staking (spool in center).

protective helmet where $\frac{3}{32}$-in. stock is drawn $3\frac{1}{2}$ in. on a $7\frac{1}{2}$-in.-dia opening.

Punching is done with two kinds of precision: Rough punching uses the lowest cost dies, is rapid and economical, but leaves a fractured raw edge and is limited to stock thicknesses through $\frac{1}{4}$ in.; smooth shaving uses a contour die ground to a sharp edge that slopes away at 45°. The edge shaves stock when the part is forced into the die while the latter is closing against a soft-steel die plate. This produces smooth edges in parts up to 1 in. thick. Holes can be punched easily, but should be generally spaced from each other and from any edge by at least the thickness of the stock. Noncircular holes and counterbores should be made circular for machining when the stock thickness specified is too thick to punch.

Stamping letters and numerals into the surface of vulcanized fibre in the punch-press operation produces permanently legible markings with no increase in cost of the part. White or colored roll leaf characters can also be impressed into the surface to give color contrast at very little added cost. Punched parts are also readily printed with rubber stamp.

Machining is usually limited to screw-machine operations on fibre tube or bar stock although flat stock too thick to punch is often drilled, counterbored or tapped. Here, deep holes and threads should be avoided in a direction parallel to fibre laminations. For screw-machine parts, tungsten carbide-tipped tools work best, running at about double the spindle speeds used with ferrous metals. Realistic tolerances for bushings are given in Table III. These total tolerances have been adjusted for expected dimensional change due to fluctuating humidity, and can be split with more of the range on the minus than on the plus side (or the opposite). When machined or as-manufactured surfaces must be knurled, a straight knurl (parallel to axis of bar or tube) is preferable.

Swaging of vulcanized fibre is akin to cold heading in metals—the material is shaped in three dimensions between metal dies in a punching operation, using either flat stock or tubing. Fibre is much less ductile than metal, so shapes designed for swaging must be much less complex. Bushings, both electrical and mechanical, are the most commonly swaged parts and most fibre manufacturers have hundreds of dies available. Covering many diameters, these stock dies permit cost savings as high as 50% over cost of machining the parts from rod or tube stock. In many cases, stock dies can be altered slightly for new designs, lowering cost even further.

Most economical design of parts swaged from flat stock should follow the dimensional limits given in Table IV. Keeping within these limits permits manufacture in a single, inexpensive punch-press operation. Top or bottom surfaces may be curved to fit cylindrical or spherical housings as needed. Holes may be round, square or irregular in shape.

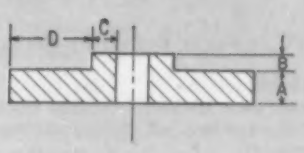
Fibre tube is also ductile enough for punch-press swaging. One end can be swaged inward to near closure, the precise amount depending on tube diameter, wall thickness and amount of wrinkling permitted as shown in Table V. Swaging a tube outward is more difficult because the material tends to tear. Grommeting is an extreme form of outward swaging—here an annular head is upset on the end of the tube. This technique can insulate openings for electrical leads in metal frames, or fasten fibre parts together. Grommeted flanges must not exceed $\frac{3}{32}$ in. regardless of tubing OD and thickness.

Extrusion is an extension of the swaging process—here it does not refer to forming long lengths of the material

TABLE III — TOTAL MACHINING TOLERANCES FOR BUSHINGS

Diameter, in.	Boring ID, in.	Turning OD, in. (Box-type tool)	Turning OD, in. (Form-roll tool)
1/4	0.006	0.006	0.008
1/2	0.006	0.006	0.010
3/4	0.008	0.008	0.012
1	0.008	0.010	0.015

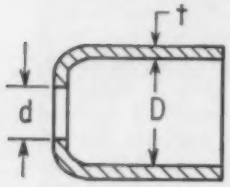
TABLE IV — LIMITING DIMENSIONS FOR SWAGED BUSHINGS



A—Not less than 0.060 in.
B—Not more than 50% of A
C—Not less than 0.060 in.
D—Not less than 0.090 in.

TABLE V — LIMITING DIAMETERS FOR INWARDLY SWAGED TUBING

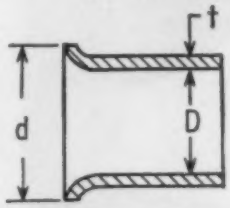
(Values are approximate; all dimensions in inches)



Tubing dia D	Diameter d after swaging, with — Minor wrinkling for t equal: 1/32	1/16	3/32	Pronounced wrinkling for t equal: 1/32	1/16	3/32
1/2	3/8	5/16	5/16	1/4	1/4	1/4
1	13/16	3/4	11/16	1/2	7/16	7/16
2	...	1-3/4	1-5/8	...	1-1/2	1-1/4

TABLE VI — LIMITING DIAMETERS FOR OUTWARDLY SPUN TUBING

(Values are approximate; all dimensions in inches)



Tubing dia D	Diameter d after spinning for t equal: 1/32	1/16	3/32
1/2	17/32	9/16	9/16
1	.....	1-3/32	1-1/8
2	.....	2-3/16	2-7/32

with constant cross-section. It is used when requirements fall outside good design practice for swaging, or when a cavity is needed on one side of a bushing. For good design, the length of extruded shank should not exceed 40% of stock thickness, and should have a total tolerance of at least 0.015 in.

Spinning provides a way of opening or closing the end of a fibre tube in a tapered manner. The end can be expanded this way about 10% of the original diameter, as shown in Table VI, or compressed approximately twice the wall thickness.

Folding, after scoring or creasing, allows flat stock to be easily folded into complex, rectilinear shapes—a switchbox liner, for example. Scoring is done by cutting about halfway through the thickness of the material, so that the uncut portion acts as a hinge. This method is recommended for thicknesses over 0.020 in. Under this thickness, creasing is recommended. This is done by impressing the material with a thin bead at the bend line, and does not reduce insulating strength at the bend as scoring does. Both operations are performed with solid dies when fibre thickness exceeds $\frac{1}{8}$ in. Up to and including $\frac{1}{8}$ in., inexpensive steel rule dies will suffice when wider tolerances are acceptable.

Storing Vulcanized Fibre

For best results, when parts are to be fabricated from vulcanized fibre or stock in primary forms of rolls, sheets, tubes or rods, the material should be stored so as to avoid extremes in either temperature or humidity. This will keep it in best condition for forming and fabricating, and avoid wide changes in dimensions or excessive warping.

For such condition in temperate zones, precautions are needed only in the winter months. The outside relative humidity is at a good level all through the year, but inside heated rooms this humidity drops very low in winter months. Most trouble is caused by letting the moisture content fall well below 50%.

This can be avoided in winter months by storing the fibre in an unheated room. It must be allowed to warm up in the fabricating department before forming, but this takes only a few hours, or a day at most. If full control of the storage room can be provided, a relative humidity of 50% ±5% at approximately 74 F is recommended as a mean condition.

Unusual Fibre Materials

There are several variants of vulcanized fibre developed for jobs where conventional fibre, in its usual forms or sizes, is inadequate. Here are three such specialty materials:

Laminated fibre, for machining complex shapes, was developed to reduce warpage and dimensional change in thick sections, and to extend available thickness to 4 in. By conventional processing, top thickness is about 1¾ in. and manufacturing time for thicknesses over 1 in. is lengthy—up to 1 year in some cases. By press-laminating $\frac{1}{32}$-in.-thick plies of gray commercial-grade fibre with a moisture-resistant, non-arc-tracking, thermosetting adhesive, stock is made available for large, intricate parts like arc extinguishers in high-voltage switch gear assemblies.

Phenolic laminates and vulcanized fibre are laminated together to combine structural stiffness of the phenolics with the non-arc-tracking and arc-extinguishing characteristics of fibre—which, by itself, is not acceptable as the sole support of a current-carrying part. The phenolic laminate core will retain its stiffness under moist operating conditions. The composite laminate can be punched, and scored for folding up to $\frac{1}{16}$ in. thick.

Rubber-surfaced fibre was designed for hermetic sealing applications where special properties of fibre were also required. Examples are combination oil seal and thrust washer for electric motors, capacitor-can top washers, and relay covers. Most elastomers that take adhesives well can be specified.

For REPRINT of above article, just check P48 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: Recent articles on materials and processes that depend upon fibrous raw materials, either natural or synthetic, include:

Which Process for Fiberglass-reinforced Plastic Molded Parts, Jan 11 '60, p 47—special report selects 7 key processes out of the 15 available, explains their strong and weak points, and shows how one or the other becomes the logical choice in most commercial volume applications.

Coatings and Fabrics for Today's Diaphragms, Oct 26 '59, p 68—selection charts guide you to the right base fabric and elastomer coating for the job.

Applications and Treatments for Felts, Mid-Oct '57, p C-8—discusses five treatments that give felts special properties and summarizes the engineering situations where they find use.

Fiber-base Structural Materials, Feb '57, p 164—ready-reference chart lists properties of three vulcanized fibre grades, compares them to those of six other load-bearing materials based on natural fibrous materials.

5 EXPERIMENTS IN TECHNICAL WRITING

The authors decided to test these five "rules" of good writing. Some are true; others are not.

JOSEPH H BLOOM and SETH A GOLDSTEIN
Rensselaer Polytechnic Institute

In these experiments, the general procedure was the same: two versions of a piece of technical writing–one the original version, the other the special variation (abstracted, summarized, repetitive, "easier," or pictorial)–were presented to the same or comparable audiences. Tests measured comprehension, reading speed, or retention.

Are Abstracts Valuable?

Should you always write an abstract for your report? Should journals insist on an abstract preceding the article?

We tried to answer these questions by exposing the same audience to two versions of a description of aircraft detection systems. The abstracted version, though shorter, took comparatively longer to read (4 minutes for 572 words in the abstracted version, compared to 14.5 minutes for 3100 words in the original).

The key to this apparent contradiction lies in high "information density"–an academic term defining content per given number of words. We found that the rapid reader suffers most from high information density. When we tested him on how much information he had absorbed, his score was lower than that of the slow reader. It would appear that unless he is told that he is reading an abstract, the fast reader often skims right past pertinent information.

These results question the value of abstracts except for the purposes of information retrieval. It is possible that a lot of abstracting wastes the writer's time and many people object to reading such highly condensed material.

Summaries: Useful or Not?

In technical writing the abstract condenses everything from the beginning to the end, the summary picks out only the highlights or orients the reader to important facts. Reports, for example, usually have summaries at beginning and end. Therefore, the same question raised in connection with abstracts can be asked here: Is too much emphasis being placed on the summary?

We gave two versions of a piece of technical writing –one with a summary and one without–to the same audience and found that reader comprehension and retention improved noticeably when summaries preceded the main article. Apparently they soften that first rough contact with a technical subject.

Do Repetition and Emphasis Help?

All writers agree that a certain amount of repetition and emphasis of important facts is absolutely necessary. But too often, the technical writer confines this to the opening and closing statements of his article. He ends it there, hoping the reader can take care of himself throughout the rest. Well, the reader may–if he knows as much about the subject as the writer does. More often than not, he loses track of the salient facts in the mass of detail.

We found that reader retention increases with two practices: (1) constant repetition of important facts and ideas, and (2) highlighting these same facts and ideas with attention-getters–underlining, capitalization, charts, color. To prove this, we presented three comparable audiences with three versions of a technical advertisement about textile dyestuffs as taken from a commercial magazine. One was the original as designed by the company; a second repeated important information over and over again; a third reduced the information to tables and listings.

The result? The second and third groups, those receiving the repetitive and highlighted versions, retained considerably more information than the first group.

Do Shorter Words Increase Reading Speed?

Not according to the results of these experiments. Two groups of college students were presented with a paper on a highly academic subject. It was full of abstract words, long sentences, and abstruse ideas. One group received the article in its original form–written for a college-level audience according to a popular reading formula. The other group read the same article rewritten for a sixth-grade level. Results showed that the reading speed and comprehension were approximately the same in each case and, if anything, the use of shorter words hampered the process.

It might be concluded from this research that the best way to communicate is to use the level of your readers as a guide: don't oversimplify a piece of copy that is to be presented to a high level audience, and, conversely, don't go "highbrow" on what is to reach a lower level of readers.

Is a Picture Worth 1000 Words?

Pictures or sketches may work both for or against the technical writer. Their effect was pointed up in the last experiment of our series.

A building was described in words and one group of readers was asked to draw the floorplan from this verbal description. Another group was shown exterior views of the building and asked to draw the floorplan. There was one correct solution. Both groups came out with about the same number of correct plans. But the group shown the picture added, in many cases, things that were not asked for, indicating that their imaginations were more stimulated than those in the first group.

The technical writer can apply the findings of this experiment as he wishes. Sometimes it may be that this visual stimulation complicates rather than clarifies the reading material; at other times it undoubtedly enhances the total effect.

Where These Experiments Are Heading

Where will these experiments lead us? Admittedly the Rensselaer tests do need further application, and each academic year will add more to our understanding of the communication process. Some topics slated for the future will deal with the use of rigid outlines, technical reporting techniques, further study of readability formulas, and the human factors in writing.

EDITOR'S NOTE: For more guidance in report writing see, **Eight Steps to Better Engineering Writing**, Sep 7 through Oct 26, 1959.

when to specify

CENTRALIZED LUBRICATION

It's a matter of choosing among five basic systems. In his guide the author also lists eight factors that determine whether centralized lubrication is preferable to point-to-point manual methods.

E J GESDORF, *senior application engineer*
The Farval Div
Eaton Manufacturing Co, Cleveland

Machine maintenance, especially lubrication, is no longer the exclusive responsibility of the plant engineer and the grease monkey. Individual machines are becoming more complex and expensive. And the constantly increasing capital expenditures for new equipment are shifting an increasing amount of the responsibility for wear-prevention to the designer. One way to solve complex lubrication problems is to use a centralized system. Here are some guides to follow in determining when the cost of such a system is justified.

In general, costs range from about $3 per bearing point for light-duty systems, to over $10 per point for heavy-duty automatic systems. Costs depend on type of system, pumping unit and lubricant; type and number of bearings, interlocking and automatic devices; the number of flexible connections and length and size of piping runs. Each machine has its own requirements that need careful analysis before the exact cost per bearing point is established.

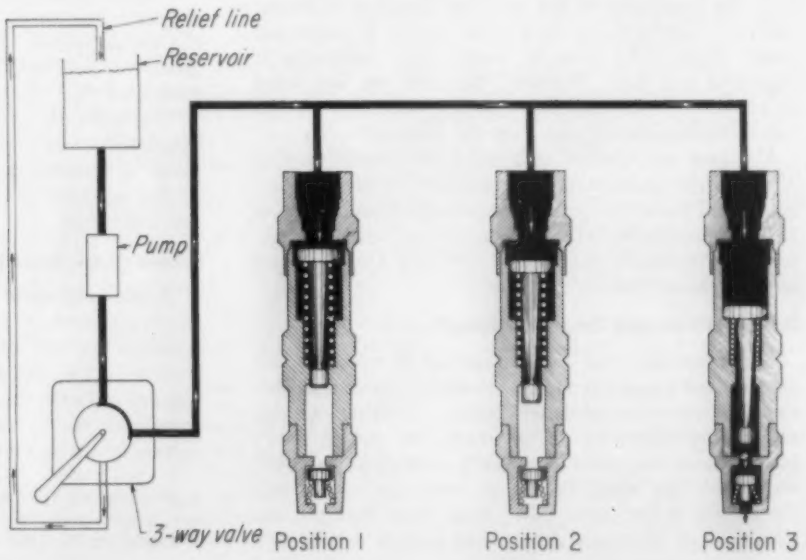
Then this cost, regardless of how low or high, must be compared to the cost of manual lubrication. Manual methods run as high as $4 in labor to apply $1 worth of lubricant. On the other hand, a central lubrication system can send a predetermined amount of lubricant to each bearing point, say, every 20 minutes for hundreds of operating hours, without need for manual attention. In such a case, even a price of $10 or more per bearing point could be economical.

CHOOSING THE RIGHT SYSTEM

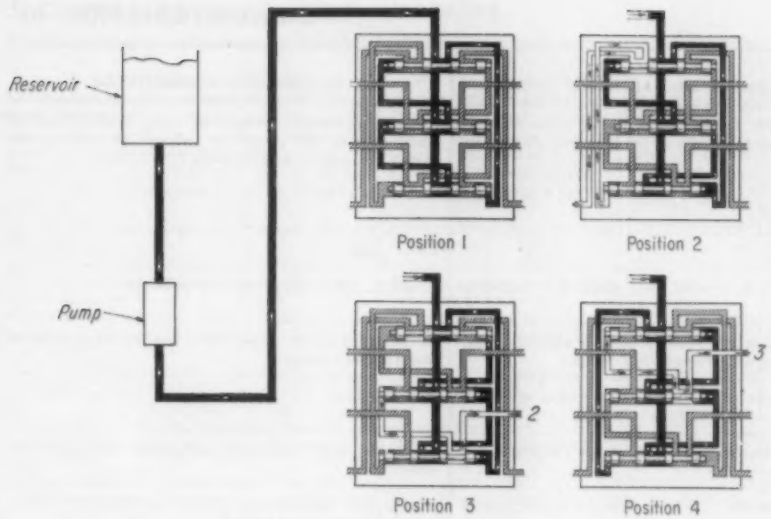
Central lubrication ranges all the way from hand-operated systems to those that are heavy-duty and automatically controlled, and are made in a wide variety of sizes and auxiliary accessories. Before deciding how complex a system to specify, consider how many of these advantages are of importance:

1. Correct lubrication of every bearing
2. Continuous high-speed machine operation
3. Reduced repairs and longer machine life
4. Increased productive output of machine
5. No contamination of lubricant or product
6. Reduced operating costs
7. Elimination of personal-injury hazards
8. Lubrication of inaccessible or inconvenient points

For example, a spring-winding machine may have 24 lubrication points, including cams, eccentrics, gears, plain and antifriction bearings, but require only a simple, manual unit if it is to operate intermittently. Another example: A high-speed printing or packaging machine would probably call for an automatic system with accessories such as alarms, lights, signals and interlocking equipment.



SINGLE-LINE SYSTEM with spring-actuated valves must vent the pressure between cycles.



A PROGRESSIVE NONREVERSING SYSTEM uses valves to perform the cycling.

FIVE TYPES OF SYSTEMS

Single-line, with spring-return valves, can be equipped with indicators and adjustments at each valve. With the pump operating, and the 3-way valve in charging position, a pressure in the line forces the piston in the measuring line to discharge the lubricant ahead of it into the bearing point. Pumping is continued until all valves have discharged. This is indicated by a poppet stem or pressure gage.

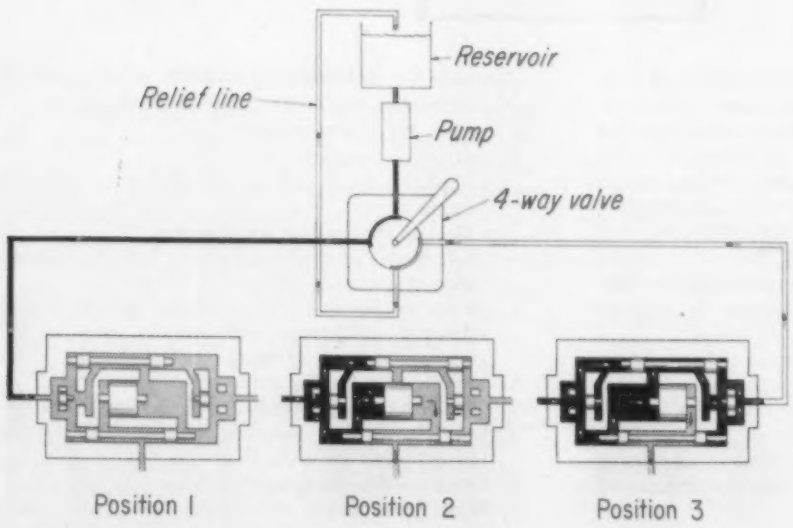
To recycle, the hand lever of the 3-way valve is turned 90° and the system exhausted through the relief line. This causes springs in the measuring valves to return the pistons for recharging.

Progressive non-reversing, with slide valves, divides the pump displacement into several bearing outlets. These valves are progressive and nonadjustable, with a system indicator usually located at the pump. When the pump operates, lubricant is brought from the reservoir to the measuring valves. These valves are continuous-cycling as long as there is flow from the pump.

Progressive reversible-flow employs a loop system with measuring valves that have three line connections. Lubricant is directed to each measuring valve through one inlet; pumping is continued until all measuring valves have operated, and flow of lubricant has returned to 4-way valve, where an indicator shows completed cycle.

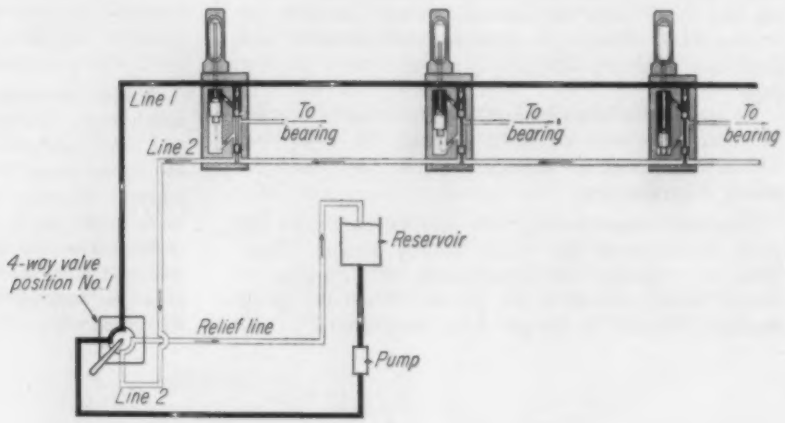
Dualine alternates the pressure between the two main supply lines. The measuring valves operate independently and offer indication and adjustment for each bearing. When the pump is operated with the 4-way valve in the position shown, p 58, lubricant goes from reservoir into main supply line 1, from where it is directed to top inlet of the measuring valve. To recycle, hand lever of the 4-way valve is shifted 90°. This directs the flow through line 2, which supplies lubricant to the bottom inlet of the measuring valve.

continued, next page



PROGRESSIVE REVERSING SYSTEM has valves arranged in loop series with reverse flow for each cycle.

THEIR FEATURES	1. SINGLE-LINE, SPRING-ACTUATED VALVE	2. PROGRESSIVE, NONREVERSING
Principle of Operation	Piston displacement. Pressure moves pistons in one direction to discharge lubricant. Spring force returns pistons for reloading.	Piston displacement. Measuring valve divides flow of lubricant from the pump into several bearing outlets. System will cycle as long as pump is operated.
Lubricant	Oil or grease	Oil or grease
Main System Elements	Reservoir, pump, 3-way valve, main supply line, measuring valves.	Reservoir, pump, measuring-valve manifolds.
Indication	Available either with or without indicators at each measuring valve—depending on manufacturer's design.	Available at pump or measuring valves, depending on manufacturer's design.
Measuring-valve Discharge	Adjustable and nonadjustable measuring valves are available, depending on manufacturer's design.	Nonadjustable
Pump Discharge	Adjustable cycle frequency, fixed discharge per stroke.	Adjustable cycle frequency, adjustable discharge per stroke.
Pumping Equipment	Manual and automatic (air power, hydraulic power, electric power).	Manual and automatic (air power, hydraulic power, electric power and power takeoff).
Application	Small, single-purpose machines involving short pumping distances. Can add or remove points of lubrication conveniently.	Small and medium-size machines involving short pumping distances. Cannot add or remove points without destroying system balance. Cannot plug unused discharge ports.



DUALINE SYSTEM alternates the flow for each cycle between the two lines.

Single-line orifice-metering supplies a number of bearing points, each equipped with a fixed orifice. The number of bearing points can be varied to the extent that the pump displacement can be increased or decreased. However, there is no adjustment at the orifices. Pressure gages can be located at various junctions.

HOW MUCH LUBRICANT?

For sleeve bearings it is generally assumed that one-third the bearing-clearance volume should be replaced every 4 hours for grease—or every 2 hours for oil.

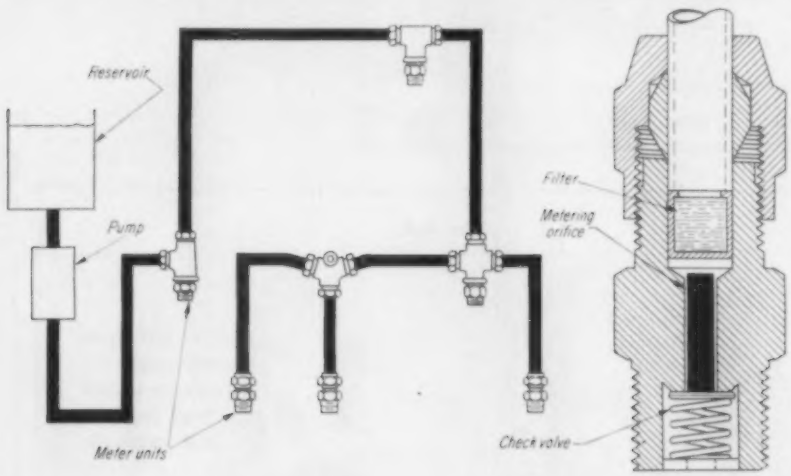
For ball or roller bearings the amount of lubricant required is usually determined by empirical formulas that allocate 0.003 to 0.005 cu in. of lubricant per inch of shaft diameter. From this, the size of the individual bearing valve is determined, and the total of all bearing requirements becomes basis for selecting the system and size of pumping unit.

Procedure we use for a progressive nonreversing system to analyze bearing requirements, select valves and accessories involves the following steps:

1. Make a bearing list.
2. Calculate bearing makeup volume in cu in. for each bearing.
3. Calculate total system requirements.
4. Make sketch of machine, showing location of lubrication points with reference numbers.
5. Divide the bearings into convenient groups, so that lubricant requirement and pressure drop to the various branches is as nearly equal as possible.
6. Identify each bearing group with a letter.
7. Calculate total requirement in cu in. for each group.
8. Select valves with capacities to satisfy both group manifold and the main line.
9. Select suitable pumping unit.
10. Select accessories.

5 CENTRAL LUBRICATION SYSTEMS

3. PROGRESSIVE, REVERSING	4. DUALINE	5. SINGLE-LINE, ORIFICE-METERING
Piston displacement. Measuring valves are piped in a loop in series fashion. Lubricant flows in one direction, moving pistons to discharge lubricant. Reversing lubricant flow in main loop moves pistons in opposite direction to again discharge lubricant.	Piston displacement. Pressure in one of two main supply lines moves pistons to discharge lubricant. System is recycled by building pressure in second supply line to move pistons in opposite direction and again discharge lubricant.	Orifice metering. Pump discharges a quantity of oil into the main supply line. Metering units (valves containing fixed orifices) proportion correct amount of the entire discharge to each bearing in the system.
Oil or grease	Oil or grease	Oil only
Reservoir, pump, 4-way valve, main supply line, measuring valves.	Reservoir, pump, 4-way valve, two main supply lines, measuring valves.	Reservoir, pump, main supply line, fittings, meter units.
Indication is provided at pump only.	Each measuring valve has its own telltale indicator.	Pressure gage
Nonadjustable	Fully adjustable	Nonadjustable
Adjustable cycle frequency, fixed discharge per stroke.	Adjustable cycle frequency, fixed discharge per stroke.	Adjustable cycle frequency, adjustable pump delivery.
Manual and automatic (air power, electric power).	Manual and automatic (air power, electric power, hydraulic power).	Manual and automatic (power takeoff, hydraulic power, electric power).
For large machinery—not generally used on machine tools. Can add or remove lubrication points, but cannot plug unused discharge ports.	For large, medium and small installations. Can add or remove lubrication points conveniently. Can plug unused discharge ports if desirable.	Light-duty, single-purpose machines. Can add or remove lubrication points, but must readjust system to compensate.



SINGLE-LINE orifice-metering system—one pump cycle—simultaneously supplies all bearing points.

WHICH LUBRICANTS

Lubricants should always be selected to first satisfy the bearing requirements. Where many different types of bearings are grouped into one lubricating system, it is necessary to reconcile two or more different lubricant specifications. In some instances, a high-grade lubricant specified for some bearings will be found suitable for all. In other situations an entirely different lubricant will be needed. But a central lubrication system will reduce total lubricant consumption, and upgrading of specification is not likely to increase lubrication expense.

In general, manufacturers of centralized lubricating systems seldom make recommendations on lubricants, as they feel this is the responsibility of lubricant suppliers. However, they can guide the user as to the consistency, pumpability and stability requirements, which are important characteristics affecting lubricating system performance. For best results the system with the broadest range of lubricant handling ability gives the greatest freedom in lubricant selection.

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EDITOR'S NOTE: For additional information on lubrication:

ASME Symposium—Wear of Lubricated Surfaces—Apr 13 '59, p 74. Gives special report on radioactive tracer technique to evaluate the effect of lubricants in preventing wear.

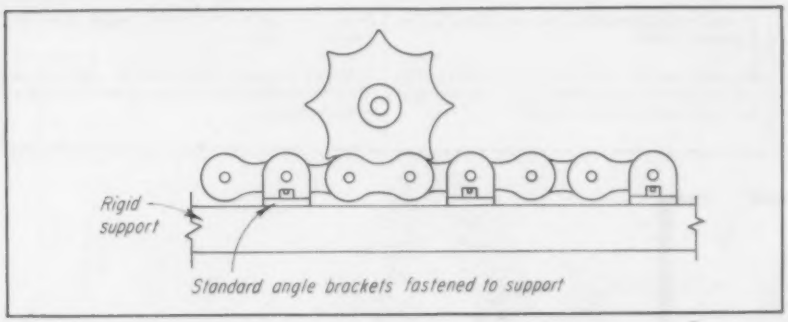
Guide to Lubricants for Instrument Ballbearings—June 9, '58, p 66. Gives properties and performance characteristics of 42 candidates and includes a review of significant military specifications. Tables quickly locate desired specifications.

Selecting the Right Plain Bearing Lubricant—Mar '53, p 134. Guide selects lubricating oils for various speeds and loads.

6 INGENIOUS JOBS for ROLLER CHAIN

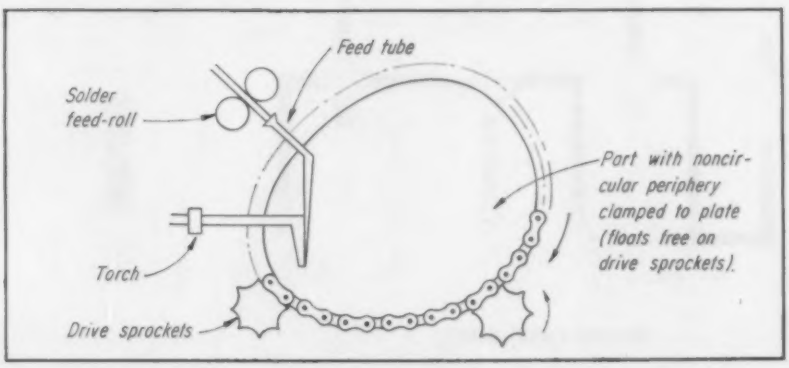
How this low-cost industrial workhorse can be harnessed in a variety of ways to perform tasks other than simply transmitting power. More examples will be presented in a coming issue.

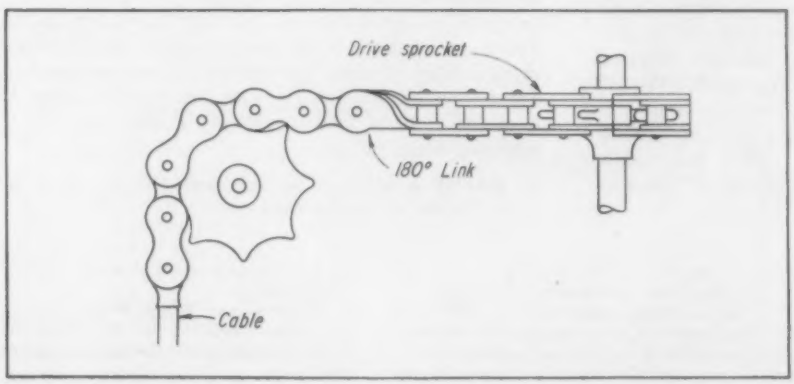
PETER C NOY, *manufacturing engineer*
Canadian General Electric Co Ltd, Barrie, Ont



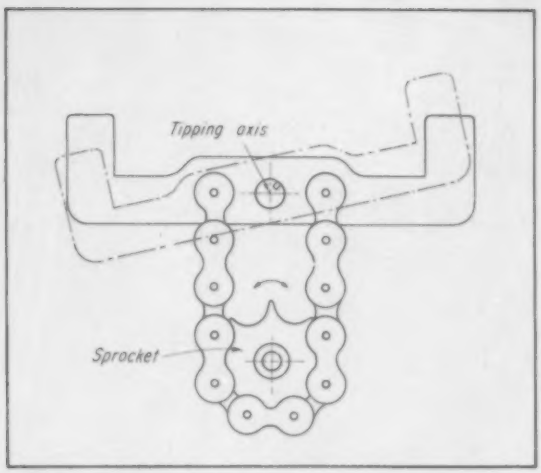
1 LOW-COST RACK-AND-PINION device is easily assembled from standard parts.

2 AN EXTENSION OF RACK-AND-PINION PRINCIPLE—soldering fixture for noncircular shells. Positive-action cams can be similarly designed. Standard angle brackets attach chain to cam or fixture plate.

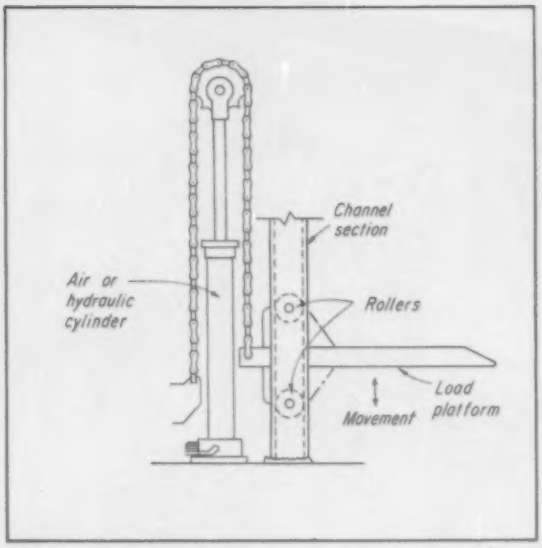




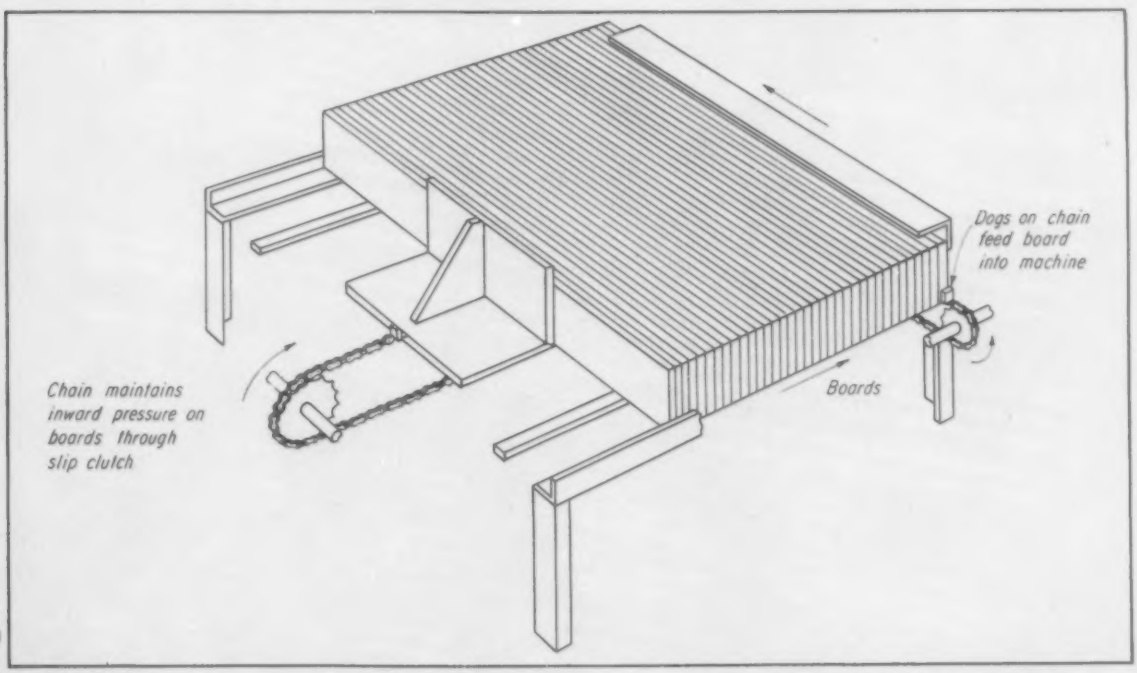
3 CONTROL-CABLE DIRECTION-CHANGER extensively used in aircraft.



4 TRANSMISSION OF TIPPING OR ROCKING MOTION. Can be combined with previous example (3) to transmit this type of motion to a remote location and around obstructions. Tipping angle should not exceed 40° approx.

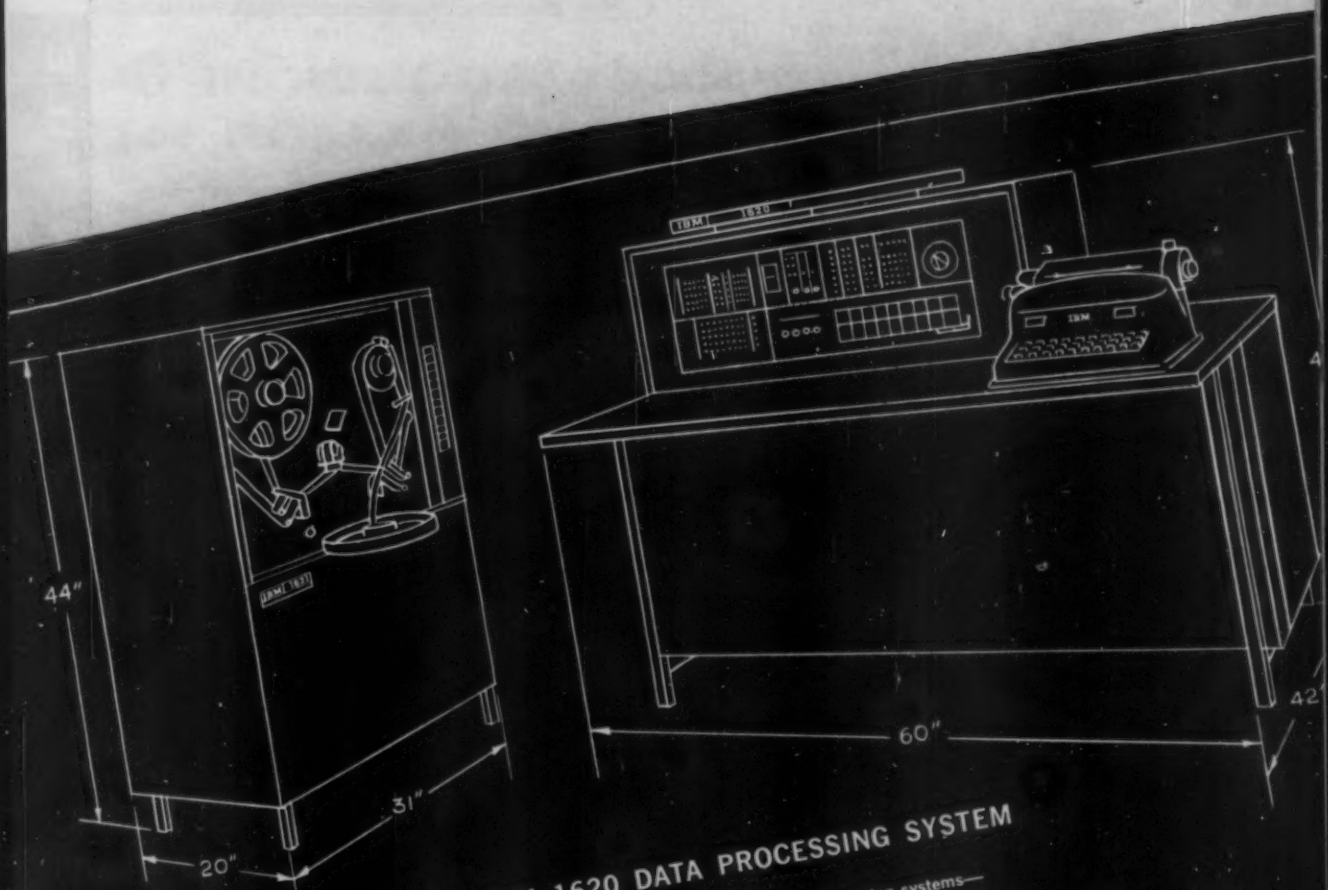


5 LIFTING DEVICE is simplified by roller chain.



6 TWO EXAMPLES OF INDEXING AND FEEDING uses of roller chain are shown here in a setup that feeds plywood strips into a brush-making machine. Advantages of roller chain as used here are flexibility and long feed.

CIRCLE 62 ON READER SERVICE CARD→



SPECIFICATIONS: IBM 1620 DATA PROCESSING SYSTEM

Core storage—20,000 digits
Automatic operation—stored programming
High computing speed—20 microsecond machine cycle
Powerful instructions with two data addresses
Decimal and alphabetic
Variable field and record length—any size numbers

Advanced programming systems—
Fortran and symbolic programming
Compatibility with other computers through Fortran
Simple console with logging features
Self checking throughout
Transistorized circuitry—
compact, economical, reliable
Paper tape input and output

The 1620 will meet technical computing requirements too complex for the conventional desk-type calculator. It provides many advantages of larger systems at a much lower cost. In addition, it can be used to support other data processing systems such as the IBM 650, 704, 705, 709, 7070 and 7090.

Information enters the system from the typewriter of the 1620 Central Processing Unit, or from the 1621 Paper Tape Reader. Output is to the typewriter or 961 Tape Punch.

Machine	Weight in lbs.	Current Requirements	Power cord	Interconnecting cable	Heat Load Specification BTU/Hr
1620	1,000	20 Amps., 115 Volts, single phase	10' 3-Wire for 115 and 230 Volts	10' signal	5,000
		10 Amps., 230 Volts, single phase		10' power	
		6.5 Amps., 208 Volts, three phase	10' 4-Wire for 208 Volts	—	2,000
1621	280	—	—	—	

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...SOLVES WIDE RANGE OF SPECIALIZED PROBLEMS

Problems that used to tie up your engineering staff for days can now be solved . . . with electronic accuracy . . . in minutes! The IBM 1620 is a low-cost, desk-size engineering computer that solves a tremendous range of routine and specialized engineering problems quickly and easily. The 1620 offers you an economical way to increase staff productivity, helps pave the way for profitable growth.

The 1620 is easy to learn, easy to operate, easy to communicate with. It adapts readily to specialized and general problems such as design development, blending problems involving matrix arithmetic, research calculations with differential equations. It facilitates the development of mathematical models for plant and shop operation, and evaluation studies employing statistical techniques such as regression analysis.

IBM also makes available a comprehensive library of mathematical routines and programs as well as reliable customer engineering. These services supporting the 1620 are an important part of IBM Balanced Data Processing. They make it easy for you to make full use of the 1620 in your operations without delay. Like all IBM data processing equipment, the 1620 may be purchased or leased.

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_____
(engineering application)

NAME _____

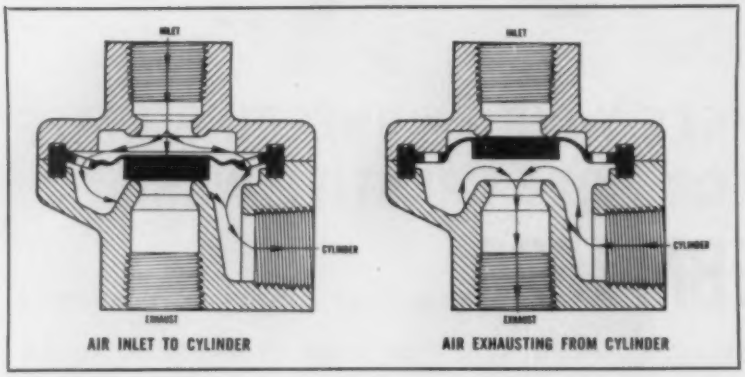
POSITION _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES

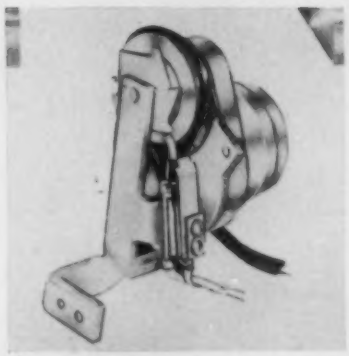


AIR INLET TO CYLINDER — AIR EXHAUSTING FROM CYLINDER

Exhaust air valve . . .

has oversize internal passages and one-piece molded diaphragm and seal to provide quick, complete venting of exhaust air from cylinders and air-operated equipment. Eliminates need for large-diameter piping and large selector valves ordinarily required to accommodate exhaust air moving back through system. Air moving through inlet port seats center section of diaphragm, closes exhaust port and unseats 12 holes that are spaced around periphery of diaphragm, permitting air to move into cylinder. Max resistance is offered to air, as combined area of 12 holes exceeds inlet port area. In exhaust cycle, inlet pressure is relieved by actuating selector valve in control circuit. Cylinder return pressure building up over entire diaphragm area closes inlet holes and snaps seated section off exhaust port to permit quick evacuation of air. Operates in any position. For ⅜-in. pipe. Recommended operating pressures are 125 psi max; 5 psi min. **Auto-Ponents Inc, 3001 Grant St, Bellwood, Ill.**

Circle 300 on Reader Service Card

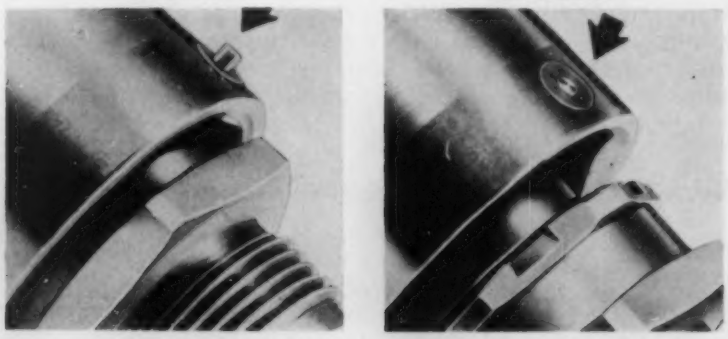


Governor detects low speeds

below 100 rpm. Based on differential measurement between known input speed and speed to be detected, centrifugal governor is said to be capable of detecting speeds accurately as low as ½ rpm. A single, or a high and low limit, can be detected on each speed. Unit operates on speed alone, independent of voltage, load or other environmental factors. Reported to have service life to 1,500,000 cycles. Furnished as completely housed unit. Can be incorporated into almost any circuitry. Recommended for automatic shifting of machine-tool transmissions, protection of low-speed equipment, sequencing of automated systems. **Torq Engineered Products Inc, Bedford, Ohio.**

Circle 302 on Reader Service Card

LOCKED — UNLOCKED



Self-sealing coupling . . .

for use in low-pressure hydraulic, pneumatic and other systems provides positive locking and offers three check points to verify connection . . . an audible click action, indicator pins that protrude externally when coupling is locked, and the position of indicator pin, which can be determined manually. Couplings connect with single, one-hand movement. Thread action of nut gives mechanical advantage that permits connection against line pressures ranging up to 60 psi. Yet coupling is reported not to disconnect accidentally even under forces applied in operation up to 20 g. Available in various end fitting configurations. **Aeroquip Corp, Jackson, Mich.**

Circle 301 on Reader Service Card

Solid-state program timer . . .

counts timed impulses with decade cascade system similar to that of abacus. Cascade of six ring-counter decades counts each pulse of 400 cps time-base signal with millisec accuracy, to pinpoint 16 different operations within a million-count period of about 45 min. Programing can be changed within a few minutes without disturbing associated wiring or connections. Operates on 22-35 v dc. Max current drain is 0.2 amp. Weighs less than 9 lb; measures 4.5 x 7 x 8 in. Said to withstand temperatures of —4 to 230 F; 100-g shock lasting 6 millisec; 15-g vibration at 60 to 2000 cps. Suitable for programing any sequence of events, such as automated operations in testing, process control of manufacturing. Price, $10,000 each. Delivery, 60 days. **Jordan Electronics, Div Victoreen Instrument Co, 3025 W Mission Rd, Alhambra, Calif.**

continued on page 66

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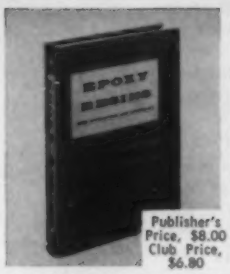

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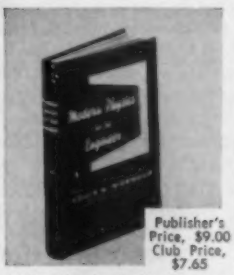
Epoxy Resins by H. Lee and K. Neville. Complete guide to the field covering chemical preparation and industrial applications.



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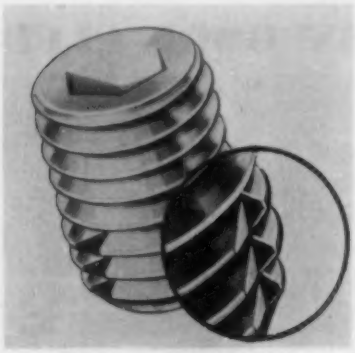

Self-tapping setscrew . . .

gathers metal and plastic chips into oversize flutes. Cutting-in action takes place at lower three threads of screw. Can also be used for sizing poorly tapped holes and for insertion in paint-filled holes. Slabbed, slotted or socket heads are available. **Set Screw & Mfg Co, Bartlett, Ill.**

Circle 304 on Reader Service Card

All-nickel forming dies, patterns . . .

and other geometric shapes are made by gas deposition technique that uses nickel carbonyl (PE—Apr 11 '60, p 21). Molding process, which eliminates machining, produces pure nickel shells, backed or unbacked with steel plate. Said to be 10 to 25% cheaper for producing complex shapes with compound curves. Method produces pattern or die that is exact duplicate of master. Finished product is reported to be highly resistant to abrasion, surpassing sand abrasive resistance of aluminum, bronze and chrome vanadium steel. Carbonyl nickel has fine grain structure, surface smoothness and nonadhesion to other metals. Tensile strength is rated 85,000 to 95,000 lb. Delivery of shapes, 4 to 6 wk. **Budd Co, Carbonyl Metal Products Div, 904 Ridge Pike, Conshohocken, Penna.**

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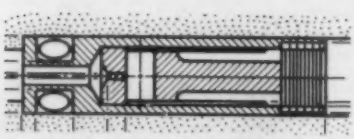


Filtered orifice . . .

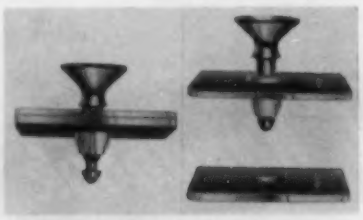
is for service to 3000 psi and 800 F. Stainless steel unit filters small quantities of line residue integrally with lubrication or flow-metering orifice. Orifice sizes range from 0.001 to 0.032 in. dia, within ±0.0001. Aluminum units are also available. List prices from $10 to $75. Delivery, 4 to 5 wk. **Research Products Inc, Box 125, Wallingford, Penna.**

Circle 306 on Reader Service Card

Stackable pressure transducers

include absolute, gage and bi- and unidirectional differential pressure transducers. Subminiature units have compensated temperature range of —65 to 250 F. Ambient temperature limits are —100 to 275 F. Nonlinearity and hysteresis is less than ±0.75% of full-scale output. Units each weigh about 4 oz. Absolute models have range of 0-5 to 0-5000 psia, providing 42 to 56 milliv nominal output with 7 v dc or ac excitation. Gage units range from 0-5 to 0-5000 psig. Rated for nominal output of 30 to 40 milliv with 5 v dc or ac excitation. Bidirectional differential types vary from ±2.5 to ±25 psi. Rated for ±20 milliv nominal output with 5 v dc or ac excitation. Unidirectional differential units have 0.5 to 0.1000 psi range Output is 40 milliv at 5 v dc or ac excitation. **Statham Instruments Inc, 12401 W Olympic Blvd, Los Angeles 64.**

Circle 307 on Reader Service Card



Plunger-type fastener assembly . . .

fastens panels, doors, drawer fronts and other sections. Composed of molded grommet and a metal plunger, both of which remain captive in removable panel or door. To fasten, assembly is inserted through hole in fixed section. Pressing plunger forces grommet fingers to expand on inside of hole to greater diameter than hole itself. Retraction of plunger collapses fingers, permitting assembly to be withdrawn. Grommet construction enables it to float and to overcome misalignment of holes. Single size accommodates range of thicknesses. **Hartwell Co, 9035 Venice Blvd, Los Angeles 34.**

Circle 308 on Reader Service Card

Miniature electrical switch . . .

is said to cost about one-third less than conventional industrial and commercial switches of its class because automatic manufacturing technique molds switch mechanism right into phenolic case. Cover is then snapped on. Rated 10 amp for across-the-board use. Also said to be less than one-half the size of conventional switch. SPDT device is available with pin plunger, lever action or bushing mount. List price is 68¢. **Appliance and Automotive Div, Controls Co of America, 9555 Soreng Ave, Schiller Park, Ill.**

Circle 309 on Reader Service Card

Four hydraulic power pumps . . .

capable of developing 10,000 psi continuous pressure are powered by self-contained, ¾ hp, 115 to 230 v ac, single-phase, constant-speed (1725 rpm), capacitor-type electric motor. Have pumping capacity of 150 cu in. per min. at pressures up to 150 psi and automatic changeover to 30 cu in. per min. up to 10,000 psi. Usable oil volume in all four models is 260 cu in. Motor can be started under load while ram is held in position under pressure. Furnished with outlet block having two ¾ in. NPT and pipe outlets for pressure take-off and return. Series consists of basic power pump with outlet block; power pump with two-way control valve for high-pressure ram advance only; power pump with four-way control valve for high-pressure advance and low-pressure return of ram; power pump with spool-type, four-way control valve for high-pressure advance and low-pressure return of ram. **Greenlee Tool Co, Rockford, Ill.**

Circle 310 on Reader Service Card

Shuttle valve . . .

with no-time-lag poppet, is for operating pressures to 3000 psi with forged aluminum-alloy body. Pressurizing either of opposing ports controls flow and gives zero leakage to closed port. Service is for hydraulic fluids or inert gases with operating temperatures of —65 to 165 F. Inlet ports are for ¼-in. line and outlet port is for ⅜-in. line. Capacity of valve is based on 0.118-dia equivalent sharp-edge orifice. **Marotta Valve Corp, Boonton Ave, Boonton, NJ.**

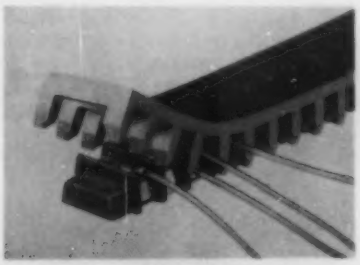
Circle 311 on Reader Service Card

Zero-leakage checkvalves . . .

are constructed with O-ring seal that provides leakproof seating at high or low pressures. One-piece valve is for service up to 5000 psi. Standard temperature range is from —65 to 275 F. Proof test, 7500 psi hydraulic pressure. Standard cracking pressure is 1 psi. For pipe sizes from ⅛ to 1 in.; tube sizes from ¼ to 1 in. Made in stainless steel, brass, aluminum and steel. Available in four styles: with

female pipe connections at both ends, female tube connections at both ends, male pipe connection on inlet and female pipe connection on outlet, or male tube connection on inlet and female tube connection on outlet. Quality Control Corp, 7315 Wilson Ave, Chicago 31.

Circle 312 on Reader Service Card



Rubber terminal-block covers

in choice of neoprene, Buna-N or silicate rubber are produced in three basic forms. One type is flexible casing with wall between each terminal pole and outer wall that is slit to allow wires to be guided through wall to terminals. Pegged edge of terminal block fits into receiving holes of cover to secure it in position. Second type is for barrier strips. Cover fits firmly into place because divider between each terminal is grooved to receive terminal strip wall. Third type is thimble-type, terminal cap for use over individual terminal pole. Opening at either side is molded into curved, protruding shield. TA Mfg Corp, 4607 Alger St, Los Angeles 39.

Circle 313 on Reader Service Card

Differential relief valve . . .

is zero-leak unit for high-pressure, pneumatic service at from −65 to 275 F. Used on ground support equipment when helium and other gases must be held for long periods without leakage. Said to crack, flow and reseat with min pressure loss. At 6500 psi ±100 psi crack, valve reseats at 6300 psi min. Handles pressures to 6500 psi and flow of 10 cfm of helium. Inlet is ½ in.; outlet is ¾ in. Connections can be AND, IPS or Aminco. Vinson Engineering & Sales Corp, 8044 Woodley Ave, Van Nuys, Calif.

Circle 314 on Reader Service Card

One-part 100% epoxy adhesive . . .

requires short heat curing to form bond, stable at 392 F, higher in certain instances. Adheres to metals, ceramics, glass, cement and other temperature-stable materials. Also is excellent insulator with high dielectric strength and low loss factor. Metachem Resins Corp, 530 Wellington Ave, Cranston 10, RI.

Circle 315 on Reader Service Card

Flexible pressure hose . . .

is comprised of precision-drawn inner core tube of inert polyamide formulation over which is braided a synthetic covering to provide high burst resistance. Black plastic is extruded over inner components to form an abrasion-resistant outer sheath. Can be used with all fluids normally encountered. Immediately available with core tube ID of $\frac{1}{16}$ in. in $\frac{1}{16}$-in. increments through ¼ in. Reported to be competitively priced. Synflex Products Div, Samuel Moore & Co, Mantua, Ohio.

Circle 316 on Reader Service Card

Urethane, two-part adhesive . . .

has high resistance to oils and solvents and develops strong elastic bonds to leather, natural and synthetic fabrics, cork, wood, nylon, phenolics and many other plastics. Mixed working life is about 18 hr. Can be applied by brush, spatula, doctor knife or roller coater. Under normal room air temperatures, assembly of parts can be accomplished in 25 to 60 min. after adhesive is applied. B B Chemical Co, sub of United Shoe Machinery Corp, 784 Memorial Dr, Cambridge, Mass.

Circle 317 on Reader Service Card

One-piece, high-pressure seals

for toggle switches, pushbuttons and rotating shafts that pass through panels and housings are made of silicone rubber bonded chemically and mechanically to a locknut. Said to meet requirements of MIL-B-005423A and MIL-B-19257. Operating temperature range is −160 to 500 F. Toggle switch boots are available in three models, each in a range of thread sizes, to fit all standard toggle switches. Pushbutton boots are furnished in four standard models, with special adapter to accommodate larger sizes. Rotary shaft seals can be supplied for shafts up to ½ in. OD, with seven thread sizes available from stock. Metal Process Co, 1801 First Ave, New York 28.

Circle 318 on Reader Service Card

High-accuracy galvanometers . . .

employ 14-kt-gold suspensions in 15 standard units. Offer sensitivity to 0.5 microamp per mm in bar- and core-magnet models; short period of 3 sec; coil resistances from 20 to 1000 ohm. For original-equipment use, basic pointer movement is available uncased, as illustrated, in a variety of forms, sensitivities and dynamic properties. Also available mounted in molded cases. Winslow Co, 701 Lehigh Ave, Union, NJ.

Circle 319 on Reader Service Card

Bronze-bushed pillow block . . .

permits replacement of worn bushing, or liner, without removing bottom half of housing from its support. Line includes split journal bearings (two-bolt) for standard power-transmission-shaft sizes from $1\frac{1}{16}$ to $2\frac{1}{16}$ in.; rigid pillow blocks (four-bolt) for shafts from $3\frac{7}{16}$ to 8 in. and angle pillow blocks for all standard transmission shafts. Dodge Mfg Corp, Mishawaka, Ind.

Circle 320 on Reader Service Card

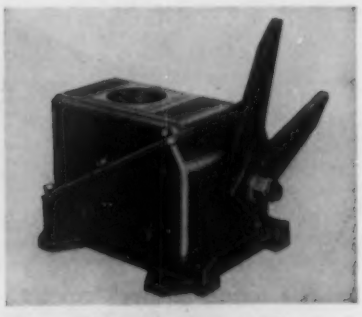
High-pressure synthetic hose . . .

consists of seamless extruded inner tube of virgin polyamide material, a high-tensile-strength polyester reinforcement and a cover of extruder polyamide formulation. Min burst pressure is said to be 9000 to 12,000 psi, depending on size. Temperature range is −40 to 225 F. Reported to offer up to seven times the flex-fatigue resistance of SAE 100 R1 wire-braid rub-

continued on page 68

ber hose; up to 2½ times as much abrasion resistance, and smaller OD than rubber hose for equivalent pressure and ID size, 60% lighter in weight. Available in lengths up to 1100 ft in some sizes. Imperial Brass Mfg Co, 6300 W Howard St, Chicago 48.

Circle 321 on Reader Service Card



Heavy-duty limit switch . . . is said to be suitable for applications where travel speed is as high as 1200 fpm. Has forked operating lever made of high-impact-resisting plastic, which does not damage operating bar and reduces shock to switch parts. Square D Co, EC & M Div, 4500 Lee Rd, Cleveland 28.

Circle 322 on Reader Service Card

Transistorized switchlight . . . is plug-in unit for low-voltage circuit triggering of neon indicators. Incorporates switching function directly in one assembly with transistor driver. Can also be supplied without transistor. Switch is nonsnap, normally open, momentary-contact unit, rated at ¼ amp dc, resistive load. Eldema Corp, 1805 Belcroft Ave, El Monte, Calif.

Circle 323 on Reader Service Card

Control kit . . . is for assembly of simple control said to adapt to most electrically measurable variables. Heart of unit is continuous-reading meter-relay that permits simplified circuitry and instantaneous reset without use

continued on page 69

GEAR PROBLEMS?

—check with

FAIRFIELD!

GEAR PERFORMANCE to match the ever-increasing power and speed of modern machines is a Fairfield specialty. This is possible because Fairfield has long held a position of leadership in utilizing the most advanced methods, equipment, and techniques for producing better gears. By keeping apace with modern engineering trends, Fairfield renders an invaluable service to many of the nation's leading machinery builders.

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HERRINGBONE—(Follows Type). Sizes from 1½" to 15"

SPIRAL BEVEL—Sizes from 16 pitch, 1½" dia., to 1½ pitch, 28" dia.

STRAIGHT BEVEL—Sizes from 16 pitch, 1½" dia., to 1½ pitch, 28" dia.

HYPOID—Sizes from 1½" to 28" dia.

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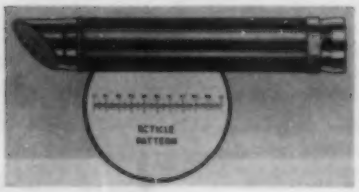

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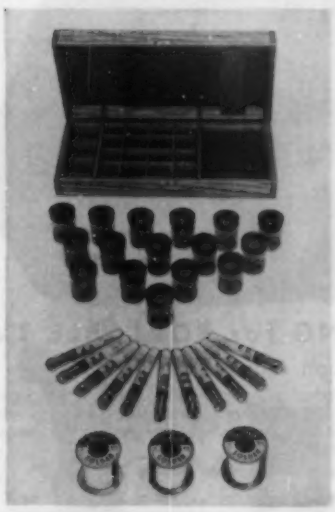

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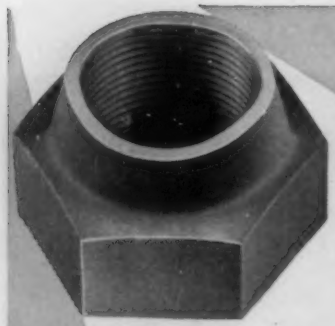

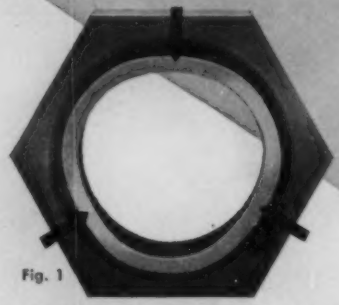

Fig. 1

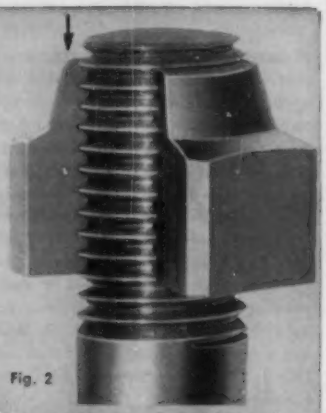

Fig. 2

Three sectors of the tapered portion of the CONELOK nut are preformed inwardly (Fig. 1). When the Nut is applied to a bolt, these conforming sectors are elastically returned to a circular configuration and create an inward and downward pressure which produces intimate contact between the load carrying flanks of the nut and bolt threads (Fig. 2). The shape of the cone sector displacement insures conformity with the mating bolt and maximum friction contact area. . . . The closed stress path in the locking portion of the nut and the advantageous distribution of locking pressure, produce a locking device of high fatigue life . . . and equivalent locking force is exerted at only a fraction of the stress of any slotted type locknut. CONELOK maintains its locking action through many re-applications. . . . It is adaptable to high, and low torque assemblies . . . to high torque stop-nut applications . . . and may be obtained in sizes from No. 10 through 1½", Full and Thick dimensions are "Standard". . .

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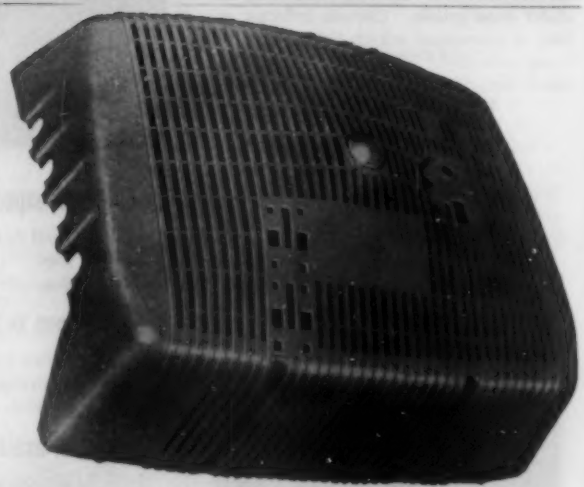

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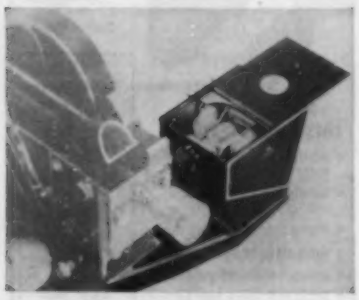

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DESIGN LITERATURE

Servomechanism Fundamentals

LAUER, LESNICK and MATSON. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6 x 9, 490 pp. $10.

This enlarged edition provides information that will help solve problems in the design of automatic control devices and help achieve efficient systems.

It presents the operating features of servomechanisms, and sets forth systematic procedures for the design of such devices. It also analyzes the elementary forms of control systems, and such servomechanisms as those with viscous-output damping, error-rate damping, and those with integral control. Typical design calculations, and other general considerations are also presented.

Characteristics of Engineers & Scientists

LEE E DANIELSON. Bureau of Industrial Relations, University of Michigan, Ann Arbor, Mich. 5¾ x 9, 136 pp. $4.

Subtitled, "Significant for their motivation and utilization", this volume reports interviews with 277 nonsupervisory professional men doing research and engineering work at ten companies near Ann Arbor, so it is a limited study in depth rather than a survey. Among them, 65% were under 35, 58% had baccalaureate degrees, 53% had been with their company less than five years, 65% had worked somewhere else, so the group seems fairly typical.

Most of the study deals with subjective information received from the engineers and scientists as well as from their supervisors. They indicate that the engineer considers himself a professional. He should have technical competence, ambition, creativity, analytical ability, and be objective, require minimum supervision and willingly assume responsibility. The study indicates the weak spots are individualism, introversion and sensitiveness—which conflict with the individuals' expressed desire in many instances to rise to management levels. Of the 277, 270 are satisfied with their jobs—higher than average, indicating that the ten companies are a preferred sample. Responses to questions in this area show a high degree of individuality.

Greatest sources of job dissatisfaction are problems in conducting research, clerical tasks, and problems in reporting, in that order. Greatest problem of the young man is to adjust to the company. There are many other conclusions, plus suggestions, providing a documented instruction manual for handling engineers. If you want to see yourself as others see you—here's the book.

Basics of Fractional Horsepower Motors and Repair

GERALD SCHWEITZER. John F Rider Inc, 116 W 14th St, NY 11. 6 x 9, 176 pp, $3.90.

Through the eyes of the repairman or electrician, the fhp electric motor with its control elements becomes a simple and logical assortment of potential trouble sources. In the book, such basic parts are brought into focus and can be easily understood. There is a wealth of illustrative material showing motors and parts, and the book will be a good quick reference for any engineer faced with choosing motors. Motors included are: universal, 3-phase, capacitor, split-phase, repulsion, shaded-pole.

Fluid Power Control

BLACKBURN, REETHOF, SHEARER. John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 6 x 9, 710 pp. $17.50.

This is a pioneer effort to present the fundamentals of the operation of power-control systems in which the working media can be either liquids or gases. Both analytical and experimental approaches to the understanding of the fundamentals are presented. The methods described can be applied to all industrial and military fields.

First, there is a good review of fluid properties and fluid mechanics. The second section, the heart of the book, deals in considerable depth with the theory and practice of hydraulic control components, with emphasis on control valves. The last two parts describe recent progress in the use of gaseous working fluids, especially high-pressure pneumatics, with concepts of system analysis and design. Given are

continued on page 73

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actual system designs based on earlier chapters of the book, with emphasis on load effects. Properties of available fluids are discussed in sufficient detail so that practical use can be made of the theory.

"Fluid Power Control" is a direct result of the research and development efforts of the staff and students in the Dynamic Analysis and Control Laboratories of the Massachusetts Institute of Technology, and has evolved in close coordination with the teaching of design and control courses in the mechanical engineering department.

Hi-temp Aircraft Wheel, Brake and Tire Assembly

GILBERT T STOUT, Bendix Products Div, Bendix Aviation Corp, (WADC Technical Report 59-210). PB 161041, Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 11, 66 pp. $2.25.

(Full title: Study and Preliminary Design of a High-temperature Aircraft Wheel, Brake, and Tire Assembly.) Design of a wheel, brake, and tire capable of operating from an ambient temperature of 800 F appears feasible. However, there are many areas which necessitate intensified study. Most prominent are mechanical-tire approaches, bearings and lubricants, and hydraulic or pneumatic dynamic seals.

The mechanical tire, and its tread material, is the most revolutionary and challenging region to be conquered. Various mechanical-tire approaches were herein considered. Designs utilizing spring configurations were more acutely investigated. Initial studies indicate that a mechanical tire possessing a spring configuration will involve a considerable weight penalty compared with the conventional wheel and casing presently being used for low-temperature applications.

Torsion Devices

P J GEARY. British Scientific Instrument Research Assn, South Hill, Chislehurst, Kent, England. 6 x 9½, 142 pp. Approx. 53.

This is the third in the British Scientific Instrument Research Assn's series of surveys of instrument parts. It reviews the design, construction and application of elastic supporting and connecting members employed in torsion. It covers: Torsion filament suspensions; employed as frictionless suspensions for the moving parts of sensitive instruments; torsion hinges (torsion members possessing flexural rigidity and used as hinges for levers and the like); and torsional magnifying devices for the magnification of small displacements and the indication of small forces.

Ingenious Mathematical Problems and Methods

L A GRAHAM, Dover Publications Inc, New York, 5¼ x 6½, 237 pp, $1.45.

The ingenious mathematical methods and problems in this book represent the original contribution of scores of skilled mathematicians to a "Private Corner for Mathematicians," conducted by the author for the past eighteen years in the Graham Transmission Inc's house organ DIAL.

For the most part the problems were contributed by DIAL's readers and it is believed that about three-fourths of them are original. Nearly all were subject to a variety of solutions, the aim being to find the most original, shortest, or simplest solution as the case may be, and so point the path to greatest pleasure, profit and prowess in the use of mathematics, as exemplified in these problems. The author states that the most striking thing about the answers received has been their lack of similarity. In nearly every case the

continued on page 74

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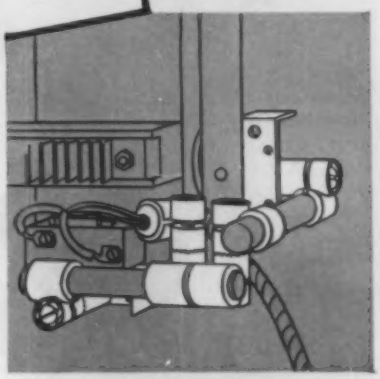

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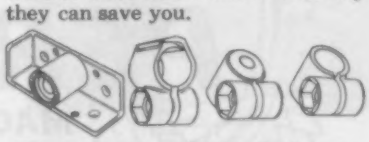

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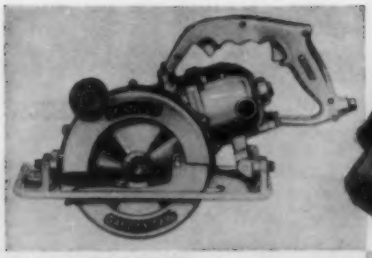

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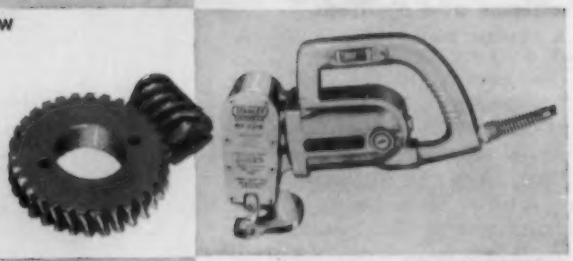

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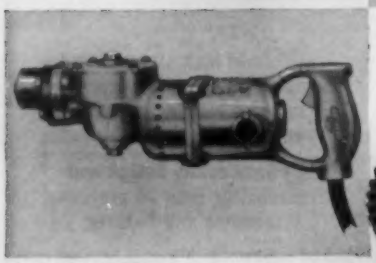

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Other Books of Interest

Tungsten

Sylvania Electric Products Inc, Towanda, Penna. 8½ x 11, 39 pp. $1.

A bibliography on the physical properties and phase diagrams of tungsten for the years 1953-1958.

ASTM Standards on Electrical Insulating Materials D-9

ASTM, 1916 Race St, Philadelphia 3. 6 x 9, 792 pp. $8.75.

Provides specifications and methods of testing.

Electrical Contacts—STP 56 M

ASTM, 1916 Race St, Philadelphia 3. 6 x 9, 44 pp. $2.50.

1958 supplement to the bibliography, and abstracts.

Detonation-induction Distances in Combustible Gaseous Mixtures at Atmospheric and Elevated Initial Pressures

151873. Bollinger and Edse. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8¼ x 10¾, 88 pp. $2.25.

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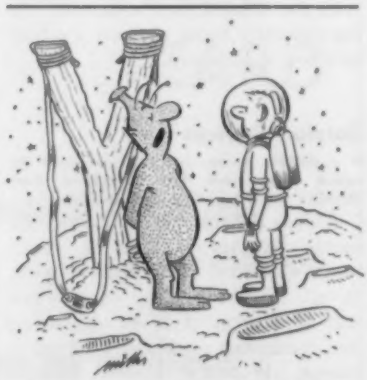

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Bibliography on Filing, Classification, and Indexing Systems for Engineering Offices and Libraries

No. 14. Engineering Societies Library, 29 W 39th St, New York 18. 8½ x 11, 33 pp. $2.

Research on Thermostable Molecules and Polymers

PB 131663. Lawton and McRitchie. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10½, 84 pp. $2.25.

Radio Amateur's Handbook

Rumford Press, Concord, NH. 6½ x 9½, 728 pp. $3.50.

Compiled by the headquarters staff of the American Radio Relay League, this is the standard manual of amateur radio communication.

Development of Inorganic Polymer Systems

PB 131935. Gibbs, Tucker, Shkapenko, Park. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10½, 55 pp. $1.75.

Reactive Metals

Edited by W R Clough. Interscience Publishers Inc, 250 5th Ave, New York 1. 6 x 9, 610 pp. $15.

Proceedings of the Third Annual Conference sponsored by Niagara Frontier Section in cooperation with The Metallurgical Society, American Institute of Mining, Metallurgical and Petroleum Engineers.

Electrical Engineering for Professional Engineers' Examinations

John Constance. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 5½ x 8, 448 pp. $9.50.

Annual Review of Nuclear Science

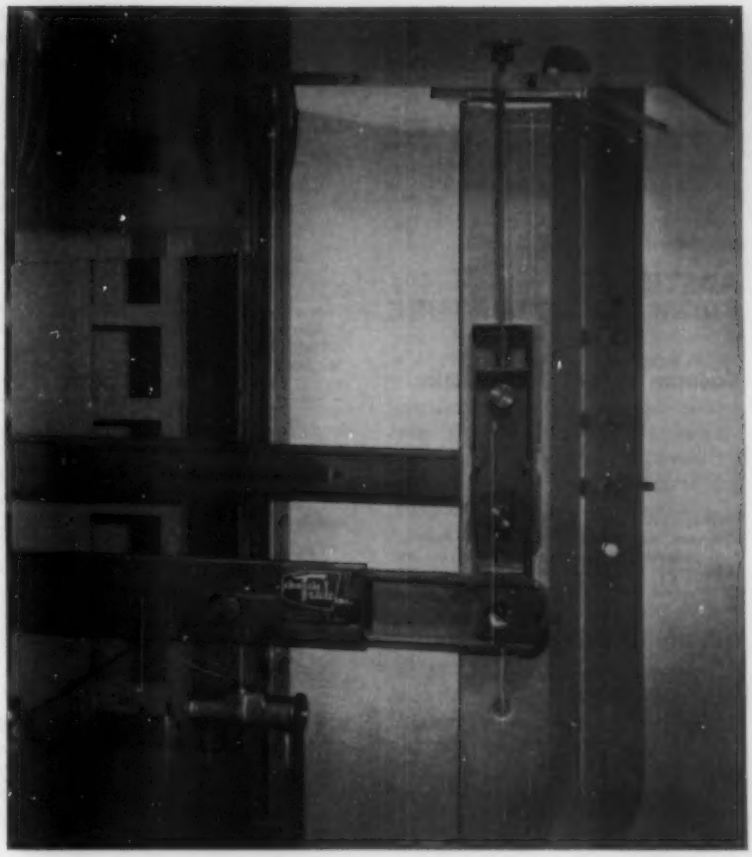
Annual Reviews Inc, Grant Ave, Palo Alto, Calif. 6 x 9, 625 pp. $7.

Industrial Instrument Servicing Handbook

Grady C Carroll. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6 x 9, 848 pp. $16.

continued on page 76

"As my pay what did you expect—Rembrandt?"



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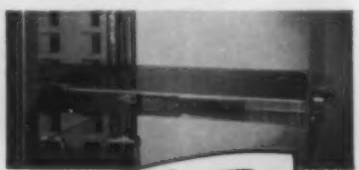
Model C-300 Detent slide shown locked in horizontal position.



chassis Trak inc.

For further information contact:

525 South Webster, Indianapolis 19, Indiana

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DESIGN LITERATURE.....continued

Cathodic Protection

Lindsay M Applegate. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6 x 9¼, 229 pp. $9.

A complete and practical guide to the use of the electrochemical means of cathodic protection to combat corrosion of underground and underwater structures.

ABSTRACTS FROM THE LITERATURE

Vacuum Metallizing Plastics

The equipment, the process and various vacuum metallized finishes for plastics are described. Special considerations applying to various types of plastics are also briefly discussed.

"Vacuum Metallizing as Related to Plastics," T. J. LaBounty, Midwest Technical Service. SPE paper 13-1. Society of Plastics Engineers Inc, 65 Prospect St, Stamford, Conn.

Quality in Fabricated Teflon

Testing procedures, causes for variations in quality of parts, how to specify properties and dimensions of fabricated Teflon are all described.

"Knowing and Recognizing Quality in Fabricated Teflon," P. E. Thomas, E. I. Du Pont de Nemours & Co Inc. SPE paper 53-1. Society of Plastics Engineers, Inc, 65 Prospect St, Stamford, Conn.

Thermoforming of Plastics

Brief descriptions and illustrations (including cross-sectional views) of equipment, materials and process involved in nine different types of vacuum and drape forming of plastic sheet are given.

"Summary of Thermoforming Techniques," R. E. Kostur, Comet Industries. SPE paper 64-1. Society of Plastics Engineers Inc, 65 Prospect St, Stamford, Conn.

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continued on page 78

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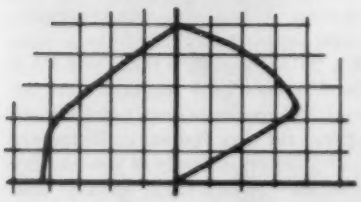

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continued on page 79

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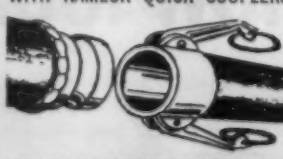

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7 Steps to Better Oral Reporting. P 42
Best Results with Printed Wiring. P 41
Elliptical Gears ..... P 40
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Faster Ways to Set Statistical Tolerances ..... P 38
4 Types of Vibrators..... P 37
Resin-Bonded Wood Compositions P 36
20 Application for Screw Threads. P 35
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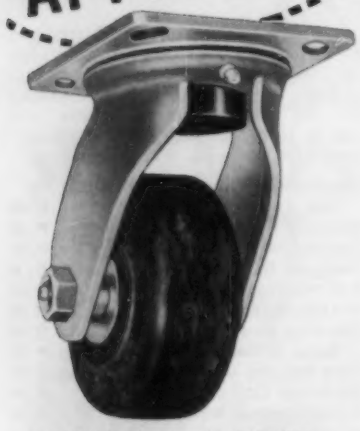

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INDEX OF PRODUCTS
ADVERTISED IN THIS ISSUE

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the READER SERVICE CARD

A

Assemblies
- Structural 73

B

Bearings
- Ball 14, 25, 81
- Miniature 14
- Oilless ..... 3rd Cover
- Roller 14
- Sleeve ..... 3rd Cover

Belts, V 22-23
Books 65
Bushings 78
Bushings, Strain Relief 78

C

Casters 80
Computers 62-63
Connectors
- Hose 36
- Tube 36

Controllers 2
Control Panels & Switchboards 72
Controls
- Pneumatic 29

Couplers 78

D

Drafting
- Supplies 76-77

Drives
- Variable Speed 22-23

E

Electrochemical Finishes & Treatments 24

F

Fastening Methods ..... 4th Cover, 7, 70

G

Gages 33-34
Gears 11, 31, 68, 74

H

Heating Units 32
Hose & Tubing 30, 36

I

Instruments
- Mechanical 33-34

M

Magnets 78
Moldings
- Plastics (see Plastic Parts)
- Powdered Metal (see Powdered Metal Parts)
- Rubber (see Rubber Parts)

N

Nuts 70

P

Photographic Equipment
- Film 28, 76-77

Pins 7
Plastic Parts 70
Plastics 18-19
Powdered Metal Parts ..... 3rd Cover
Production Machines & Processes 70
Pumps
- Liquid 72

R

Relays 38
Reproduction Supplies 28, 76-77
Resins 18-19
Rings 69
Rubber 10
Rubber Parts 10

S

Seals 35
Slides 75
Specialty Fasteners (Pipe Hangers, Special Cold Headed Parts, etc.) 4th Cover, 7, 70
Speed Increasers & Reducers 11

T

Thermostats 2
Tubing
- Flexible Metal 5, 36
- Plastic 30
- Seamless 13

V

Valves
- Air ..... 2nd Cover, 29
- Solenoid ..... 2nd Cover, 72

INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibilities for errors or omissions

A

Albion Industries, Inc. 80
Anaconda Metal Hose Div., American Brass Co. 36

B

Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div. ... 33-34
Bound Brook Oil-Less Bearing Co. ..... 3rd Cover

C

Chassis-Trak, Inc. 75
Cincinnati Gear Co. 31
Clare & Co., C. P. 38

D

du Pont de Nemours & Co., (Inc.), E. I., Polychemicals Dept. 18-19

E

Edgewater Steel Co. 69
Elastic Stop Nut Corp. of America ... 7

F

Fafnir Bearing Co. 25
Fairfield Mfg. Co., Inc. 68
Fastex Div., Illinois Tool Works ..... 4th Cover
Fenwal, Inc. 2
Flexible Tubing Corp. 5

H

Heyman Mfg. Co. 78

I

I. B. M., Data Processing Div. 62-63
Illinois Tool Works, Fastex Div. ..... 4th Cover
Industrial Electronic Engineers, Inc. .. 72

J

Johns-Manville Corp., Packings & Gaskets Div. 35

L

Link-Belt Co. 11

M

McGraw-Hill Book Co., Inc. 65
Marsh Instrument Co., Div. of Colorado Oil & Gas Corp. 72
Minnesota Mining & Mfg. Co., Microfilm Div. 76-77

N

National Machine Products Div., Standard Pressed Steel Co. 70
National Tube Div., U. S. Steel Corp. 13
New Hampshire Ball Bearings, Inc. ... 14

O

OPW-Jordan Co. 78
Ohio Rubber Co. 10

P

Perkins Machine & Gear Co. 74
Polymer Corp. of Pennsylvania 30
Post Co., Frederick 28

R

Ross Operating Valve Co. ..... 2nd Cover

S

Schaefer Machine Co., Inc. 70
Sinko Mfg. & Tool Co. 70
Stephens-Adamson Mfg. Co., Spherco Bearings & Rod Ends Div. 81
Steward Mfg. Co., D. M. 78

T

Technic, Inc. 24

U

Unistrut Products Co., Rotocon Div. .. 73
U. S. Steel Corp., National Tube Div. .. 13

V

Viking Pump Co. 72
Vulcan Electric Co. 32

W

Westinghouse Air Brake Co., Industrial Products Div. 29
Worthington Corp. 22-23

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EMPLOYMENT OPPORTUNITIES 82
Index to Advertisers appears on P. 81
Products Index appears on P. 80

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P30	P31	P32	P33	P34	P35	P36	P37	P38	P39
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P30	P31	P32	P33	P34	P35	P36	P37	P38	P39
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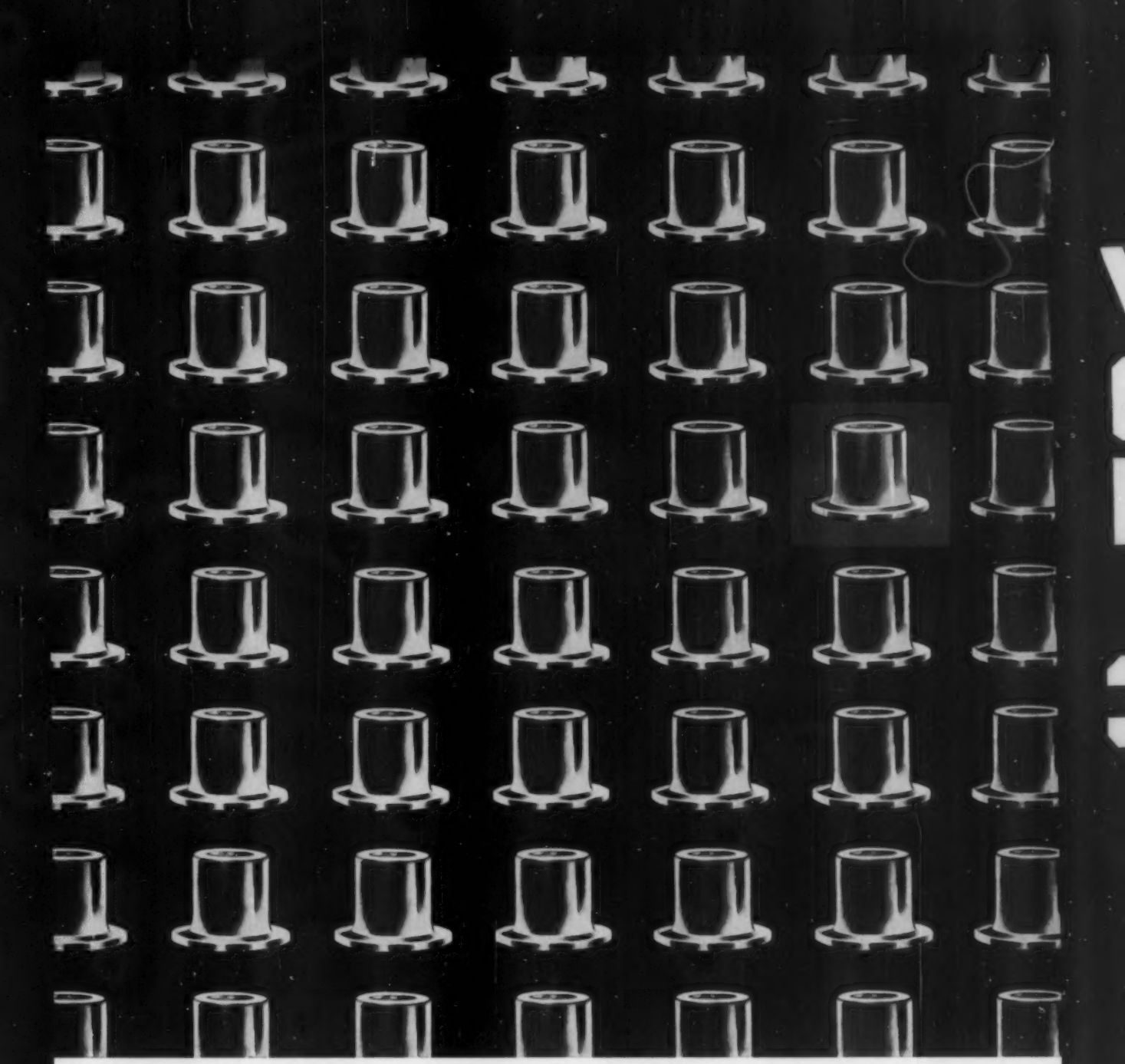

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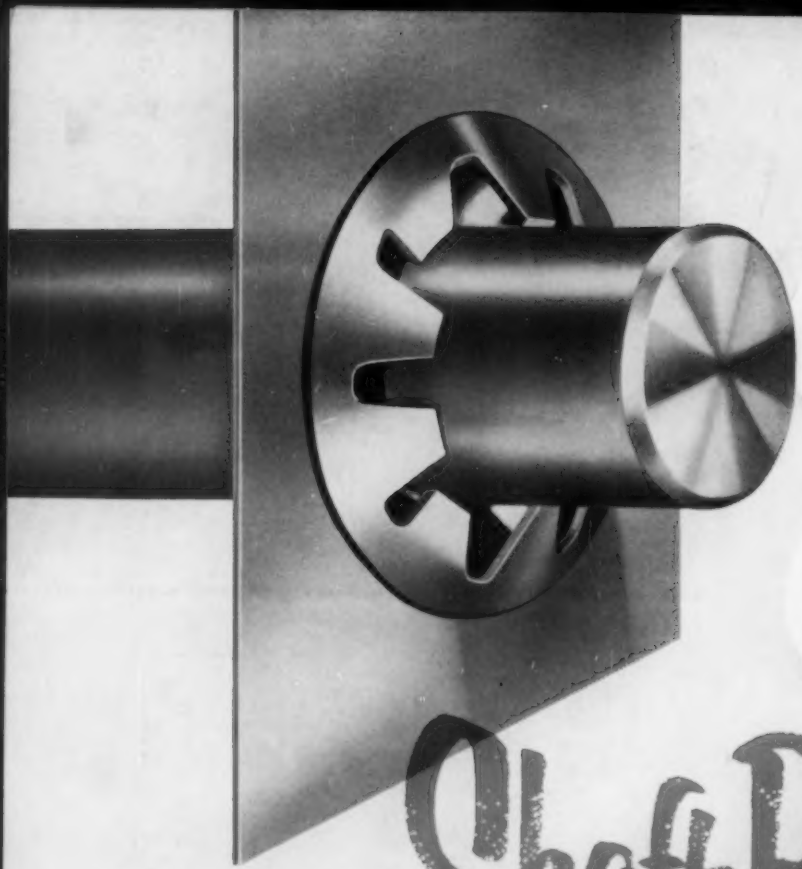

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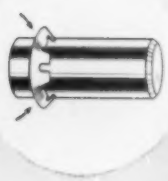

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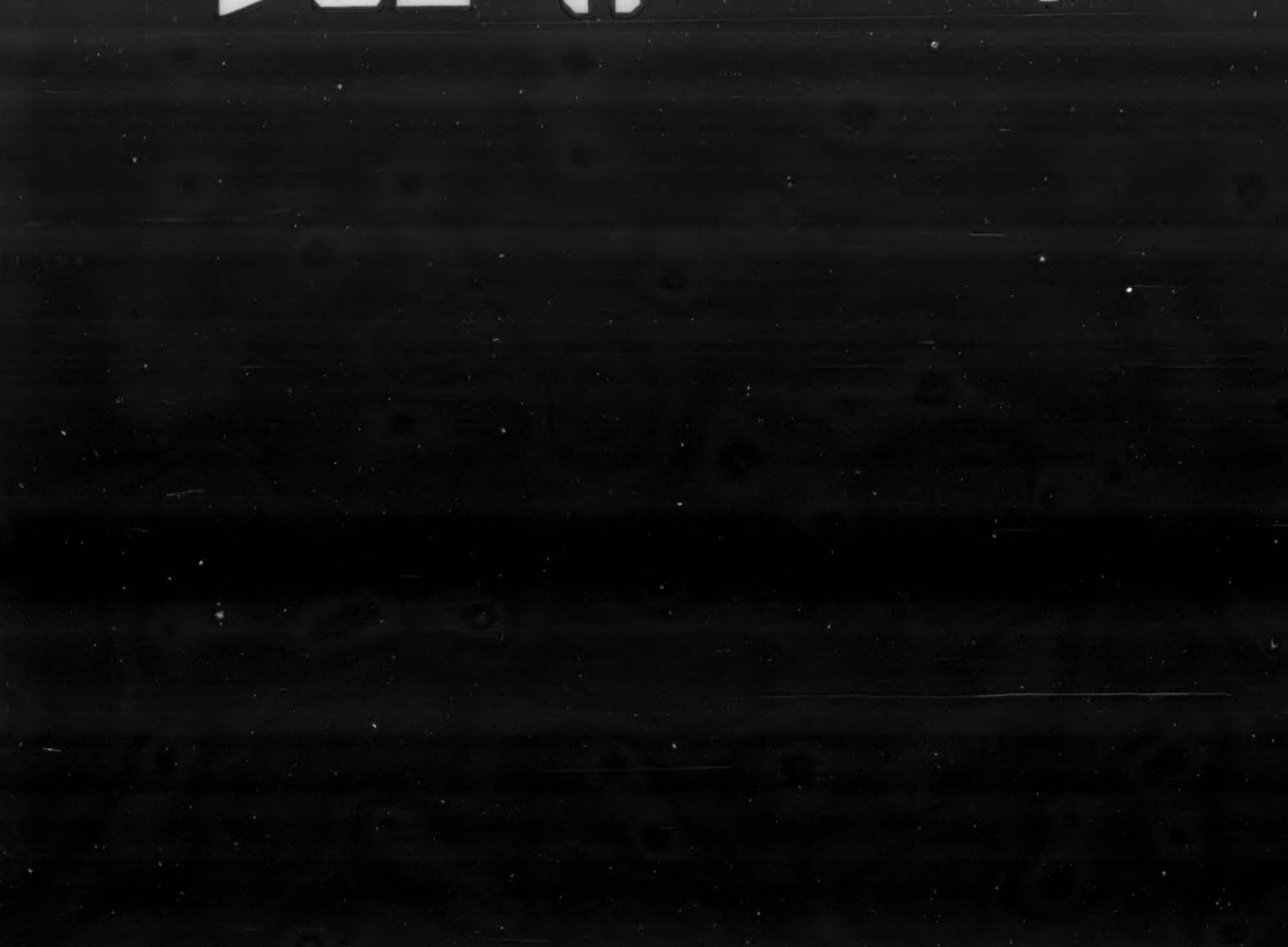
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